THE GEOMETRICAL SEA-MAN: OR, THE ART OF NAVIGATION

Performed by

GEOMETRY.

SHEWING

How all the three kinds of Sayling,

viz. { By the Plain Chart, / By *Mercators* Chart, / By a great Circle.

May be easily and exactly performed by a Plain Ruler and a pair of Compasses, without Arithmeticall Calculation.

The Second Edition much inlarged.

By HENRY PHILLIPPES.

LONDON:
Printed by ROBERT and WILLIAM LEYBORN, for GEORGE HURLOCK, and are to be sold at his Shop at *Magnus* Church-Corner, 1657.

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C

TO

The INGENIOUS, INDUSTRIOUS, and Yonger SEA-MEN.

AS it is chiefly for your profit that I write; so I hope, that though I shall be condemned of others, yet I shall gain your pardon. I confesse my labour may seeme needlesse, after so many learned Authors, to set forth any thing of this subject. And it may be accounted a presumptious folly for any to goe about to teach Sea-men in their Art, especially in these times, wherein there were never more, nor more skilfull Sea-men. But in answer hereto take notice of these considerations.

First, That many Books of this subject, though they are plain and easie for all Sea-men to understand, yet they are not so exact and perfect in all things as they ought to be.

Secondly, That though Mr. *Wright*, Mr. *Gunter*, and Mr. *Norwood*, have very fully shewed the errours of the foresaid Books, and have very perfectly reformed them; yet their Books are not plain and usefull for all men, because they require much knowledge in Arithmetick.

Thirdly, Though there be many skilfull Sea-men, which are able to make use of these Authors, yet there are many others, who would willingly attain to a more perfect knowledge in this Art, and yet cannot, for want of Arithmetick. Now for the helpe of such as these e-

specially, have I published this Book: wherein you shall finde how all that which is to be performed by Arithmetick in the foresaid Authors, may be sufficiently exactly perform'd by Geometry with the Ruler and Compasse; so that any one that can but read and write a little, though he have no skill in Arithmetick, may hereby attain a true and perfect knowledge of the Art of Navigation, so that he shall be able to keepe as true and certain an account of his Voyage in any part of the World, as one that works by the most exact rules of Arithmetick. Nay, I dare say, that one that can neither write nor read, yet being of an ingenious capacity, and having one to teach him according to this way, may attain sufficient skill in this Art.

Fourthly, This may also be usefull to those who can performe these things by Arithmetick and the Doctrine of plain Triangles: For by this way they may perform them far more easily and readily, and almost as exactly. And though such men may know many of these things already, yet perhaps they may gain some knowledge hereby.

Lastly, As by this way the knowledge of the Art is most easily and speedily attained, so it is more certainly and constantly retained and preserved, both in respect of the knowledge and practise thereof. First, the knowledge hereof is more certainly retained in your memory: for this is the reason why all Authors are forced to make use of some Geometricall figures, partly to explain their Rules, and partly to fix them in the memory, by making them visible to the eye; for we more surely remember any thing which wee see done, then what we onely hear. Now in this way, every thing is made much

much more visible to the eye, and therefore more easie both to learn and remember. Secondly, the practice of this knowledge will be more surely and constantly preserved: for Arithmeticall Calculations require many Tables, *viz.* of *Sines*, *Tangents*, *Secants*, *Meridian*, which cannot possibly be kept in memory; so that if by any crosse accident a Sea-man be deprived of his Books, he can make no use of his skill in Arithmetick. But if a man knowes how to performe these things by Geometry, though all his Books and Writings be lost, yet having but a plain Ruler and a pair of Compasses, he may quickly recover his loss, and fall to his work as before.

Upon these considerations, I have adventured to publish this little Book, wherein I have briefly and plainly laid down the whole Art (as to the Geometricall part thereof) beginning at the first Principles, and proceeding by degrees to the highest Conclusions. I have used the more Figures to make every thing the plainer. And I have provided such figures, as serve not onely for demonstration of the thing, but may serve for Instruments to work upon; or you may easily, by the directions given, make the like. To conclude, I have studied to make those things plainest, which have at any time most troubled my self to understand. So that I question not but that any one that is industrious, may here of easily and speedily attain, such a competent measure by knowledge in this Art, that by Gods blessing upon his study and labour, he may obtain much credit and profit thereby.

And of this (I hope) you have received some proofe already, as is partly manifest by the speedy sale of the former Edition: which to mee is a greater argument,

and I accept of it, as a greater teſtimony of your kinde acceptance; then if I had gained the commendatory Epiſtles of many pre-ingaged friends: who are many times ſubject to ſpeake, more in favour of their friends, then in fervour to the Truth.

And I queſtion not, but that this ſecond Edition will finde the like acceptance; wherein though I have altered nothing, (becauſe it need not) yet I have added the whole VIII. Chapter, which ſpeaks (if I miſtake not) very fully and plainly, to the chiefe buſineſs of Sayling by a great Circle. And therefore as you my former friends may here ſee ſomewhat worth your farther peruſall; ſo I doubt not, but by this ſecond Edition I ſhall alſo gaine many new ones; and by all your favours I ſhall confeſſe my ſelfe much ingaged and incouraged, and ſhall (God willing) be provided ſhortly, to make you part of amends, by a ſecond piece of this Art, of ſomewhat an higher nature. In the meane time, I ſhall remaine,

Your Philomathicus

Henry Phillippes.

Where

Where as there is ... the making of a Scale or line of Chords and Rumbes by the divided Circle: it may more exactly be done by this Table and any Scale of Equall parts, Equall to the Radius, divided into 100 or 1000 parts.

A Scale or line of Chords.

For each degree of the quadrant.

D	chord	D	chord	D	chord
1	017	31	534	61	1015
2	035	32	551	62	1030
3	052	33	568	63	1045
4	070	34	585	64	1060
5	087	35	601	65	1074
6	105	36	618	66	1089
7	122	37	635	67	1104
8	139	38	651	68	1118
9	157	39	668	69	1132
10	175	40	684	70	1147
11	192	41	700	71	1161
12	209	42	717	72	1176
13	226	43	733	73	1190
14	244	44	749	74	1204
15	261	45	765	75	1217
16	278	46	781	76	1231
17	296	47	797	77	1245
18	313	48	813	78	1259
19	330	49	830	79	1273
20	347	50	845	80	1286
21	364	51	861	81	1299
22	382	52	876	82	1312
23	398	53	892	83	1325
24	416	54	908	84	1338
25	432	55	923	85	1351
26	450	56	939	86	1364
27	466	57	954	87	1377
28	484	58	970	88	1389
29	501	59	984	89	1402
30	518	60	1000	90	1414

For each Rumbe.

Rumb	Angle		chord.
	1	02 49	049
	2	05 37	098
	3	08 26	147
1	0	11 15	196
	1	14 04	245
	2	16 52	293
	3	19 41	242
2	0	22 30	390
	1	25 19	438
	2	28 07	486
	3	30 56	533
3	0	33 45	581
	1	36 33	627
	2	39 22	674
	3	42 11	719
4	0	45 00	765
	1	47 49	811
	2	50 37	855
	3	53 26	899
5	0	56 15	943
	1	59 04	986
	2	61 52	1028
	3	64 41	1070
6	0	67 30	1111
	1	70 19	1150
	2	73 07	1191
	3	75 56	1230
7	0	78 45	1269
	1	81 34	1306
	2	84 22	1343
	3	87 11	1379
8	0	90 00	1414

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THE CONTENTS AND Order of the whole Book.

IN the two first Chapters is shewed how to perform some Geometricall Principles; which are necessary to be known, because most of the following work is done thereby.

The third Chapter shewes the making and use of the plain Chart, being the common way of sayling.

The fourth Chapter shews the making and use of the true Sea-Chart, being in many respects more perfect then the former.

The fifth Chapter shewes the way of sayling by a great Circle, being the most exact and best way of sayling that can be.

The sixth Chapter shews many usefull observations in all these kinds of sayling.

The seventh Chapter shews another way of sayling by the arch of a great Circle.

The eighth Chapter shews, How to finde the arch of a great Circle between any two places how so ever situate, by the projections of Tangents according to the Rules of the fifth Chapter.

The last Chapter shews how to keep a perfect account of any Voyage by a little common Arithmetick, viz. Addition, and Substraction.

THE

THE GEOMETRICAL SEAMAN.

OR THE Art of *Navigation* performed by GEOMETRY.

CHAP. I.

Containing some Geometricall Propositions, which will be of frequent use.

The first Propositon

PROPOSITION I.

How to erect a Perpendicular line at the end of a line.

What a perpendicular line is.

A Perpendicular line, is a line that stands directly upright from another line. As in the figure, the line B C is a perpendicular line, to the line A B. Now in the Figure there are two wayes of raising it, the one on the right side, and the other on the left.

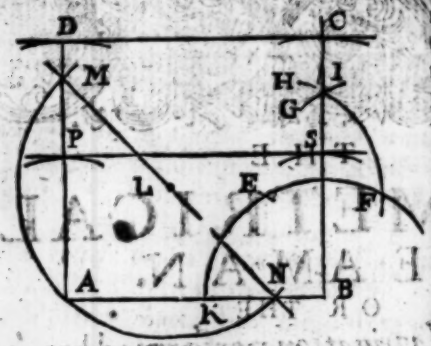
First, Let the line A B be given: and it is required to erect the line B C perpendicularly to it, at the end of the line in the point B.

How to raise a perpendicular.

To perform this: first, set one foot of your Compasses in the point B, and opening the other to any distance (you please) draw

draw the arch K E F, then keeping your Compasses at the same distance, set one foot in K, and with the other mark the former arch at E: then keeping your Compasses still at the same distance, set one foot in the mark at E, and with the other draw the arch H F, then remove one foot of your Compasses to F, and with the other draw the arch G I: lastly, lay your ruler by the cross of the two last arches at I, and the point B, and draw the line C I B, so you have performed the demand.

The first figure.



Another way. The second way to perform this, is demonstrated on the left side of the figure. Let the line A B be given as before, and it is required to erect the line A D perpendicularly in the point A.

To perform this, first, set one foot of your Compasses in any convenient point at pleasure, as at L, and open the other foot to the point A, and draw the arch N A M, then lay your ruler to the center of this arch L, and the place where it crosseth the line A B, which is at N, and draw the line M L N, which doth crosse the arch N A M in the point M. Lastly, laying your Ruler to this crosse at M, and the point A, draw the line D M A, so you shall have your desire.

PROPOSITION 2.

The second Proposition. *To draw one line parallel to another line, at any distance required.*

What is meant by a parallel line. A Line is said to be parallel to another line, when it is equally distant from it in every part thereof. Thus in the former

former figure the line P S is parallel to the line A B. Now the way to draw a parallel line is thus.

Let the line A B be the first line given, and it is required to draw the line P S parallel to it, according to the distance P A.

First, open your Compasses to the distance you have occasion to use, which in this example is P A, then setting one foot in A, with the other draw the arch at P, and then keeping your Compasses at the same distance, remove one foot to B, and with the other draw the arch at S: lastly, laying your ruler on the very edge of these two arches, draw the line P S, which will be parallel to A B, and so the proposition is performed.

PROPOSITION 3.

How to make a Geometricall Square.

The third Proposition.

A Geometricall square, is a square whose foure sides are all of one and the same length. Now in the first figure, let the line A B be the side of such a Square, and it is required to make a Square of that length and breadth.

How to make a Square.

First, you must draw the line A B according to the length given, then erect the perpendicular line A D at one end thereof, as was shewed before, then setting one foot of your compasses in the corner A, open the other to B, and keeping one foot still in A, with the other crosse the perpendicular A D at D: then keeping your compasses at the same distance, set one foot in B, and with the other draw a short arch at C, then set one foot at the crosse at D, and with the other crosse the arch last drawn in the point C: now if you draw lines through these marks, from A to D, from D to C, and from C to B, so you shall make the Geometricall Square A B C D as was required.

How to try a Square.

If you will try your work whether you have made it true or no, then set one foot of your compasses in A, and open the other to the corner at C, then with that distance, set one foot in B, and turn the other to the corner at D, if both these opposite corners have the same distance, the Square is truly made, otherwise not.

A long Square

If you would make a long ſquare, as the ſquare A P S B, firſt, you may draw the line P S parallel to A B, and according to the length of the ſide of your ſquare, then erect the perpendicular either at A or B, and draw the oppoſite ſide, parallel thereunto, according as the length of your ſquare requires: and you may try the truth of this ſquare, alſo by the oppoſite corners as before.

The fourth. Propoſition.

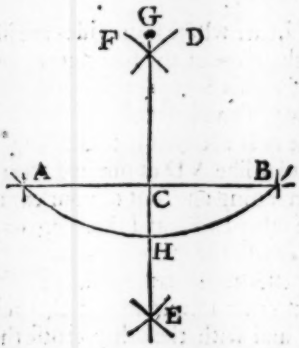
PROPOSITION 4.

To raiſe a perpendicular in the midſt of a line.

IN this ſecond figure, let A B be the line given; and it is required to raiſe a perpendicular in the point C.

First, ſet one foot of your compaſſes in the point C, and open the other to any diſtance at pleaſure, and marke the given line therewith on both ſides from C, at the points A and B, then ſetting one foot of your compaſſes in the point A, open the other to any diſtance you pleaſe beyond C, and draw a little arch above the line at F. Then with the ſame diſtance, ſet one foot in B, and with the other croſſe, the arch F with the arch D. Laſtly, lay your ruler to this croſſe, and the point C, and draw the line G C, which is perpendicular to the line A B, in the point C as was required.

The ſecond figure.



PRO-

PROPOSITION 5. *The fifth Propoſition.*

From a point aloft, to let fall a perpendicular upon a line given.

LEt G be the point aloft, from whence it is required to let fall a perpendicular upon the line A B in the ſecond figure.

Firſt, ſet one foot of your compaſſes in the point given, which is G, and open your compaſſes ſo wide that you may draw the arch A H B, which may cut the line A B in the points A and B, and the farther theſe two points are aſunder ſo much the better, then keeping your compaſſes at this diſtance, ſet one foot in A, and with the other draw the arch E, then remove one foot to B, and croſſe the laſt arch at E, laſtly, laying your ruler to the point G, and this croſſe at E, draw the line G C E, ſo you have performed the propoſition.

PROPOSITION 6. *The ſixth Propoſition.*

To draw a line ſquire wiſe to another line.

IN the ſecond figure let A B be the line given, and it is required to draw the line G E ſquire wiſe to it, ſo that it may croſſe it at right angles.

Firſt, open your compaſſes at pleaſure, and ſetting one foot in the line at B, with the other make two ſhort arches, one above the line at D, and the other below the line at E. Then with the ſame diſtance, ſet one foot in A, and with the other croſſe the two former arches at D and E. Laſtly, laying your ruler by theſe two croſſes D and E, draw the line G E, which will croſſe the line A B at right angles as was required.

PROPOSITION 7. *The ſeventh Propoſition.*

To divide a line given into two equall parts.

IN the ſecond figure let A B be the line given, to be divided into two equal parts.

Firſt, ſet one foot of your compaſſes at the one end of

the line at A, and open the other to any distance above half the line, & therewith draw two little arches one above the line at F, and the other below the line at E, then remove your Compasses to B the other end of the line, and crosse the two former arches at F and E, then lay your ruler to these two crosses F and E, and draw the line G C E, which will divide the line A B in two equal parts in the point C, so that A C is the one halfe, and C B the other.

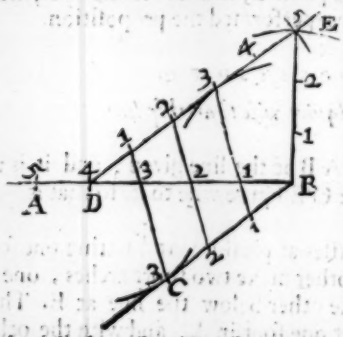
The eighth Proposition.

PROPOSITION 8.

To raise a Perpendicular at the end of a line another way.

IN this figure, let the line given be A B, and it is required to raise a perpendicular at the end thereof at B.

The third Figure.



First, divide the whole line, or a part thereof into five equal parts, of any quantity you please, as you see from B to A, then setting one foot in B, open the other to three of those parts, and with that distance keeping one foot still in B, with the other make a little arch at E, then open your Compasses to five of those parts, and setting one foot in the fourth of those parts at D, with the other crosse the former arch at E, then lay your ruler to this crosse at E, and the point B, and draw the line E B, which will be perpendicular to the line A B, as was required.

Here you may note that if the three sides of a Triangle be made of these three numbers 3 4 5, or any other numbers that are proportionable thereunto, as 6 8 10, 9 12 15, 12 16 20, 30 40 50, it will have one right angle, which will be opposite to the greatest side, as in the Triangle D B E, the side

ſide E B is 3, the ſide B D is 4, and the ſide D E is 5, and the angle at B is a right angle.

PROPOSITION 9.

The ninth Propoſition.

To make one angle equall, or like to another.

What an angle is, with the generall kinds of angles.

AN angle is the joyning or croſſing of two lines: if the two lines croſſe one another, or joyn one to another perpendicularly, then they are ſaid to make a right angle, or angles: if two lines meet or croſſe one another any other way, they are ſaid to make an oblique angle or angles.

Thus in the third figure, the lines D B and E B meeting in the point B, make a right angle. And in the ſecond figure, the lines A B and G E, croſſing one another in the point C, make four right angles, or quadrants. But in the third figure, the lines E D and B D, meeting in the point D, are ſaid to make an oblique angle. Now theſe oblique angles, if they be leſſe then a right angle, they are called acute or ſharpe angles: if they be more then a right angle, they are called obtuſe or blunt angles.

Now for example of the propoſition, let the angle E D B be the appointed angle, and it is required to make the angle D B C like unto it.

In this example, becauſe the line D B is limited, and is common to both the angles, you ſhall need onely to ſet one foot of your compaſſes in B, and open the other to the neereſt diſtance of the line D E, which you may do by drawing the little arch which toucheth the line between 3 and 4: then remove your compaſſes to D, and draw the like arch at C, then lay your Ruler to the point B, and the very edge of this arch C, and draw the line B C, ſo ſhall the two angles be of one quantity or wideneſſe, as was deſired.

In other caſes this way will not ſerve, but this is ſufficient for the preſent purpoſe, and I ſhall ſhew you other wayes to perform that in the next Chapter.

PRO-

The tenth Propoſition

PROPOSITION 10.

To divide a line into any number of equall parts.

IN the third figure, let the line B D be given, to be divided into four equall parts.

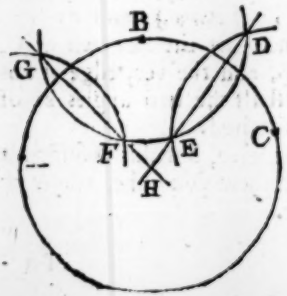
Firſt, from the end D, draw a line as D E, making an angle with the line D B at pleaſure, then from the other end of the line B make the angle D B C equall to the former angle, as was ſhewed in the laſt Propoſition. Then from the point D ſet off with your compaſſes, ſuch a number of any equal parts, as lacks one of the number deſired, which in this example, therefore muſt be 3, ſet off therefore on the line D E three equall parts 1, 2, and 3; then you muſt with the ſame diſtance of your compaſſes ſet off 1, 2, and 3, from the point B, on the line B C, then draw croſſe lines from the laſt number in the one line, to the firſt in the other, that is from 3 to 1, from 2 to 2, &c. and theſe lines will divide the line B D into four equall parts as was deſired.

The eleventh Propoſition

PROPOSITION 11.

To bring any three points, not lying in a ſtraight line, into a Circle.

IN this figure, let A B C be the three points given, and it is required to draw a circle through them all.



The fourth figure.

Set one foot of your compaſſes in the middle point at B, and open your compaſſes to any diſtance you pleaſe, ſo it be above half the diſtance, between B, and either of the other marks (yea, it is no matter if need be, though it reach almoſt to, or quite beyond the neereſt of the other marks) and draw the arch D E F G,

D E F G, then keeping your compaſſes at this diſtance, ſet one foot in A, and with the other draw the arch G F, which croſſeth the former arch at G and F, then ſet one foot of your compaſſes in the third point C, and with the other draw the arch E D, which croſſeth the firſt arch at E and D, then laying your ruler to the interſections of theſe arches; draw the lines G F H and D E H, which will croſſe one another in the point H, this croſſe at H, is the center of the Circle: therefore ſetting one foot of your compaſſe in this croſſe at H, open the other to any of the three points A B or C, and draw the circle; which if you have done well, will paſſe through all the three points A B C as was required.

CHAP. II.

Shewing how to divide a Circle ſeveral wayes which will be needful for many things.

THe firſt uſuall diviſion of a Circle, is into 24 equall parts, according to the 24 houres of a naturall day; which is thus to be performed.

To divide a Circle into 24 equall parts.

Firſt, draw a line at pleaſure, and croſſe it in the midſt with another line at right angles, then in the croſſing of theſe two lines, ſet one foot of your compaſſes, and open the other to what diſtance you pleaſe, and therewith draw the circle, which by the croſſe lines of Eaſt and Weſt, North and South in the figure, is divided into 4 equall parts or quadrants, each of them containing 6 houres apiece: ſet VI and VI, XII and XII to theſe 4 parts as in the figure; then keeping your compaſſes at the ſame diſtance wherewith you drew the circle, ſet one foot in the croſſing of the line and the circle, at VI on the one ſide, and with the other make two marks in the circle, one above and the other below, ſo ſhall you mark out the houres of II and X: then removing your compaſſes to the VI on the other ſide, mark out the houres of II and X on that ſide: Again, keeping the compaſſes ſtill at the ſame diſtance,

The tenth Propoſition

PROPOSITION 10.

To divide a line into any number of equall parts.

IN the third figure, let the line B D be given, to be divided into four equall parts.

Firſt, from the end D, draw a line as D E, making an angle with the line D B at pleaſure, then from the other end of the line B make the angle D B C equall to the former angle, as was ſhewed in the laſt Propoſition. Then from the point D ſet off with your compaſſes, ſuch a number of any equal parts, as lacks one of the number deſired, which in this example, therefore muſt be 3, ſet off therefore on the line D E three equall parts 1, 2, and 3; then you muſt with the ſame diſtance of your compaſſes ſet off 1, 2, and 3, from the point B, on the line B C, then draw croſſe lines from the laſt number in the one line, to the firſt in the other, that is from 3 to 1, from 2 to 2, &c. and theſe lines will divide the line B D into four equall parts as was deſired.

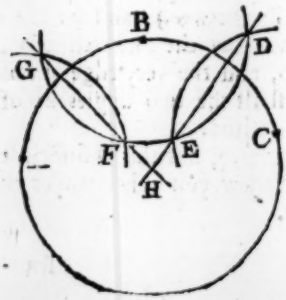
The eleventh Propoſition

PROPOSITION 11.

To bring any three points, not lying in a ſtraight line, into a Circle.

IN this figure, let A B C be the three points given, and it is required to draw a circle through them all.

The fourth figure.



Set one foot of your compaſſes in the middle point at B, and open your compaſſes to any diſtance you pleaſe, ſo it be above half the diſtance, between B, and either of the other marks (yea, it is no matter if need be, though it reach almoſt to, or quite beyond the neereſt of the other marks) and draw the arch D E F G,

D E F G, then keeping your compaſſes at this diſtance, ſet one foot in A, and with the other draw the arch G F, which croſſeth the former arch at G and F, then ſet one foot of your compaſſes in the third point C, and with the other draw the arch E D, which croſſeth the firſt arch at E and D, then laying your ruler to the interſections of theſe arches; draw the lines G F H and D E H, which will croſſe one another in the point H, this croſſe at H, is the center of the Circle: therefore ſetting one foot of your compaſſe in this croſſe at H, open the other to any of the three points A B or C, and draw the circle; which if you have done well, will paſſe through all the three points A B C as was required.

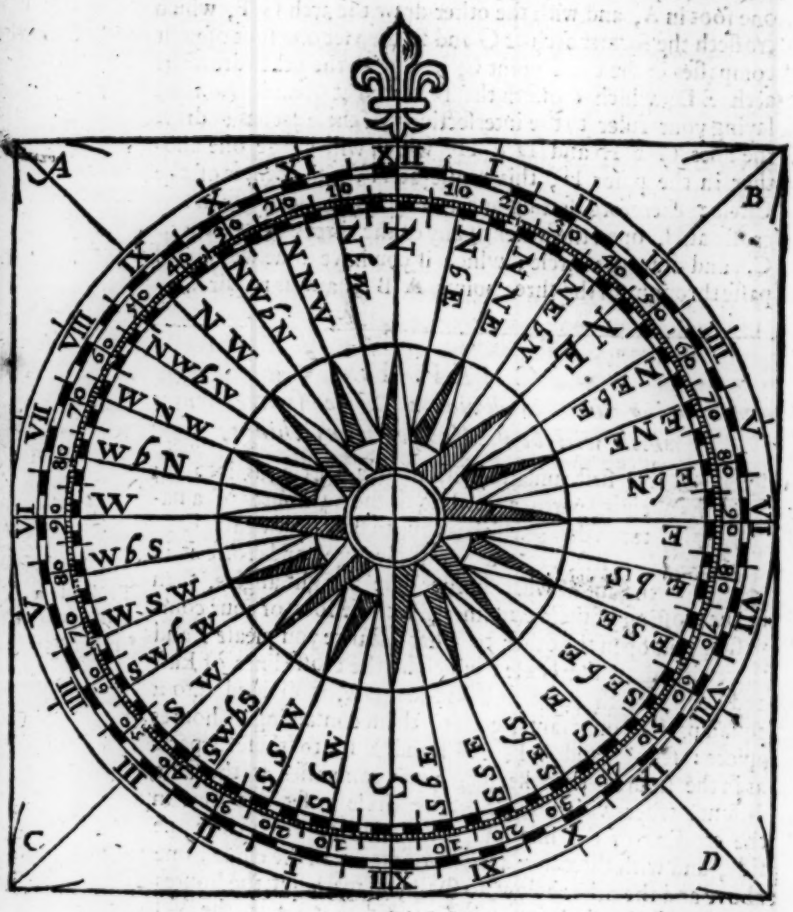
CHAP. II.

Shewing how to divide a Circle ſeveral wayes which will be needful for many things.

THe firſt uſuall diviſion of a Circle, is into 24 equall parts, according to the 24 houres of a naturall day; which is thus to be performed.

To divide a Circle into 24 equall parts.

Firſt, draw a line at pleaſure, and croſſe it in the midſt with another line at right angles, then in the croſſing of theſe two lines, ſet one foot of your compaſſes, and open the other to what diſtance you pleaſe, and therewith draw the circle, which by the croſſe lines of Eaſt and Weſt, North and South in the figure, is divided into 4 equall parts or quadrants, each of them containing 6 houres apiece: ſet VI and VI, XII and XII to theſe 4 parts as in the figure; then keeping your compaſſes at the ſame diſtance wherewith you drew the circle, ſet one foot in the croſſing of the line and the circle, at VI on the one ſide, and with the other make two marks in the circle, one above and the other below, ſo ſhall you mark out the houres of II and X: then removing your compaſſes to the VI on the other ſide, mark out the houres of II and X on that ſide: Again, keeping the compaſſes ſtill at the ſame diſtance,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ſet the one foot in the croſſing of the line and circle at the upper XII, and with the other you ſhall mark out the hours of VIII and IIII in the upper half of the circle, then remove your compaſſes to the lower XII, and ſo mark out the hours of VIII and IIII, in the lower part of the circle: thus the circle will be divided into 12 equall parts, and every one of theſe wil contain two hours apiece, and now it wil be eaſie for you to divide each of theſe parts into two, ſo you will have the 24 hours; laſtly, you may divide each hour into four equall parts which will be quarters of hours, and ſo you may number them, and draw them out as in the figure.

To divide a circle into 360 degrees.

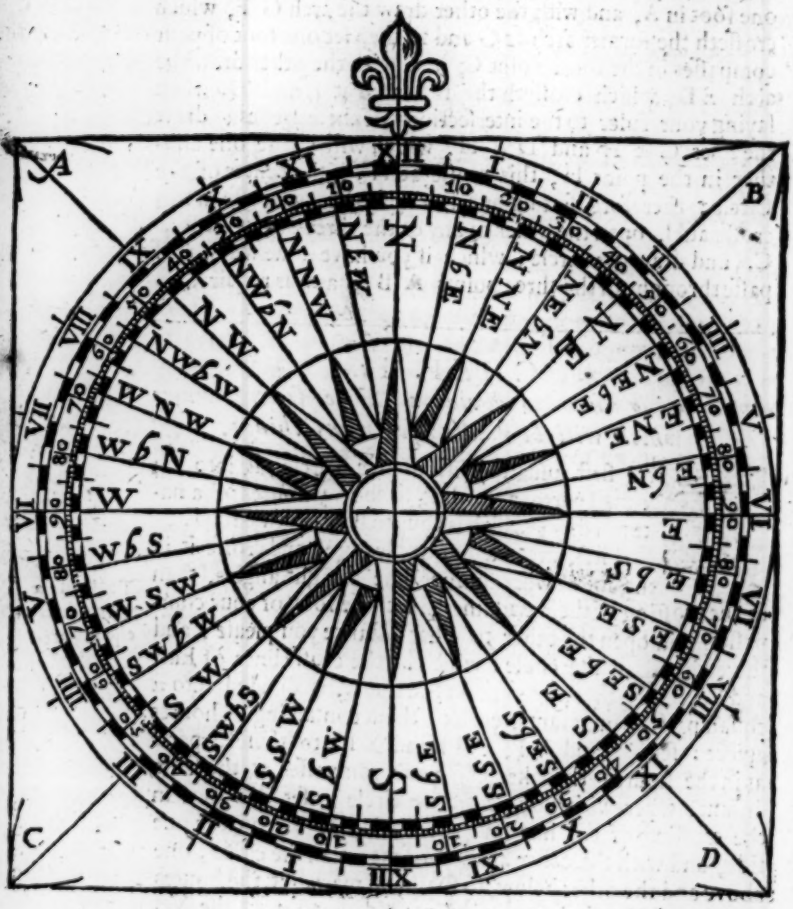
Secondly, another uſuall and neceſſary diviſion of a circle is to divide a circle into 360 equall parts. For in all queſtion of Aſtronomy, and in the calculation of all triangles, theſe parts are the meaſure of the angles, ſo that every arch in this reſpect is ſuppoſed to be divided into 360 equall parts, which are called degrees, and each degree is ſuppoſed to be divided into 60 leſſer parts called minutes. To divide a circle after this manner, the ready way is thus.

Firſt, draw a line at pleaſure, and croſſe it at right angles with another line, and draw a circle as before, then keeping your compaſſes at this diſtance, divide the circle from the four quarters into 12 equall parts as before, then cloſing your compaſſes divide each of theſe 12 parts into 3, ſo you ſhall have in all 36 parts, then you may eaſily with your pen divide each of theſe parts into 10 little parts, each of which ſtands for a degree, and ſo you may number them as in the middle circle of the figure.

To divide a circle into 32 parts.

A third uſuall diviſion of a circle is into 32 equall parts according to the number of the points of the compaſſe, which may be thus performed.

Firſt, draw the line of Eaſt and Weſt, and croſſe it at right angles with the line of North and South, and draw the circle as before, then keeping your compaſſes at that diſtance, ſet one foot where the line of Eaſt doth croſſe the circle, and with the other draw two little arches one above at B, and the other below at D: then with the ſame diſtance of your compaſſes ſet one foot where the line of weſt doth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ſet the one foot in the croſſing of the line and circle at the upper XII, and with the other you ſhall mark out the hours of VIII and IIII in the upper half of the circle, then remove your compaſſes to the lower XII, and ſo mark out the hours of VIII and IIII, in the lower part of the circle: thus the circle will be divided into 12 equall parts, and every one of theſe wil contain two hours apiece, and now it wil be eaſie for you to divide each of theſe parts into two, ſo you will have the 24 hours; laſtly, you may divide each hour into four equall parts which will be quarters of hours, and ſo you may number them, and draw them out as in the figure.

To divide a circle into 360 degrees.

Secondly, another uſuall and neceſſary diviſion of a circle is to divide a circle into 360 equall parts. For in all queſtion of Aſtronomy, and in the calculation of all triangles, theſe parts are the meaſure of the angles, ſo that every arch in this reſpect is ſuppoſed to be divided into 360 equall parts, which are called degrees, and each degree is ſuppoſed to be divided into 60 leſſer parts called minutes. To divide a circle after this manner, the ready way is thus.

Firſt, draw a line at pleaſure, and croſſe it at right angles with another line, and draw a circle as before, then keeping your compaſſes at this diſtance, divide the circle from the four quarters into 12 equall parts as before, then cloſing your compaſſes divide each of theſe 12 parts into 3, ſo you ſhall have in all 36 parts, then you may eaſily with your pen divide each of theſe parts into 10 little parts, each of which ſtands for a degree, and ſo you may number them as in the middle circle of the figure.

To divide a circle into 32 parts.

A third uſuall diviſion of a circle is into 32 equall parts according to the number of the points of the compaſſe, which may be thus performed.

Firſt, draw the line of Eaſt and Weſt, and croſſe it at right angles with the line of North and South, and draw the circle as before, then keeping your compaſſes at that diſtance, ſet one foot where the line of Eaſt doth croſſe the circle, and with the other draw two little arches one above at B, and the other below at D: then with the ſame diſtance of your compaſſes ſet one foot where the line of weſt doth

croſſe the circle, and draw two little arches like the former at A and C: then with the ſame diſtance of your compaſſes, ſet one foot where the line of North doth croſs the circle, and with the other, croſſe the two upper arches at A and B: then ſet one foot where the line of South doth croſſe the circle, and with the other croſſe the two lower arches at C and D; then laying your ruler croſſe-wayes to theſe croſſes, draw the lines A D and B C: ſo the circle ſhall be divided into eight equall parts; then cloſing your compaſſes, you may eaſily divide each of theſe 8 parts into 4, (for having divided one of them they will all fall out alike) and ſo you ſhall have the 32 rumbes or points of the compaſſe, which you may ſubdivide if you pleaſe into halues and quarters, and draw the lines, and by three or four letters expreſſe their names as in the figure, which ſignifie as followeth.

The names of the 32 points of the Compaſſe.

North	*South*
North by Weſt	*South by Eaſt*
North-North-weſt	*South-South-eaſt*
North-weſt by North	*South-eaſt by South*
North-weſt	*South-eaſt*
North-weſt by Weſt	*South-eaſt by Eaſt*
Weſt-North-weſt	*Eaſt-South-eaſt*
Weſt by North	*Eaſt by South*
Weſt	*Eaſt*
Weſt by South	*Eaſt by North*
Weſt-South-weſt	*Eaſt-North-eaſt*
South-weſt by Weſt	*North-eaſt by Eaſt*
South-weſt	*North-eaſt*
South-weſt by South	*North-eaſt by North*
South-South-weſt	*North-North-eaſt*
South by Weſt	*North by Eaſt*

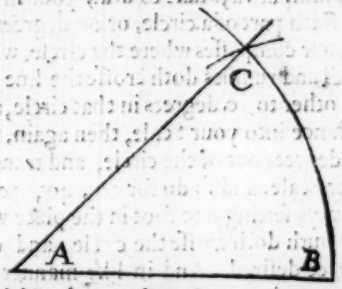
To make an angle of any quantity.

Having thus divided a circle into theſe three ſorts of parts, it will be very uſefull to you in the dividing of any other circle, quadrant, or arch, and by this circle you may eaſily draw any angle of what quantity you pleaſe.

For

For example, let A B be a line given, and it is required to draw another line from the point A, ſo that it may make an angle of 45 degrees.

Firſt, ſet one foot of your compaſſes in the center of your divided circle, and open the other to the circumference of that circle which is divided in to degrees. Then with this diſtance, ſet one foot of your compaſſes in the point A, and with the other draw the arch B C. Then again ſet one foot of your compaſſes in that place of your divided circle, where the degrees begin to be numbred, (which is where the line of North and South doth croſſe the circle) and open the other to 45 degrees of that circle; and with this diſtance ſet one foot in B, and with the other croſſe the arch B C in the point C. Then lay your ruler by the point A and the croſſe at C, and draw the line A C, ſo the angle at A made by theſe two lines A B and A C, wil be 45 degrees, as was required.



Another Example.

In like manner ſuppoſing the line A B to be the Meridian or South line, and it is required to draw a line from the point A, which ſhal repreſent the Southeaſt or the fourth Rumbe from the Meridian.

Firſt, ſet one foot of your compaſſes in the center of your divided circle, and extend the other to that circle which is divided into Rumbes, and with that diſtance draw the arch B C. Then ſetting one foot of your Compaſſes in that point where the South line and the circle croſſe each other, open the other to the line of Southeaſt, and then ſet off that diſtance from B to C in this laſt figure, then draw the line A C which will repreſent the Southeaſt as was deſired.

To make a Scale of Chords and Rumbs.

You may doe this alſo by a Scale of degrees, and Rumbes, which you may have upon a ſtraight line on your ruler, which you

croſſe the circle, and draw two little arches like the former at A and C: then with the ſame diſtance of your compaſſes, ſet one foot where the line of North doth croſs the circle, and with the other, croſſe the two upper arches at A and B: then ſet one foot where the line of South doth croſſe the circle, and with the other croſſe the two lower arches at C and D; then laying your ruler croſſe-wayes to theſe croſſes, draw the lines A D and B C: ſo the circle ſhall be divided into eight equall parts; then cloſing your compaſſes, you may eaſily divide each of theſe 8 parts into 4, (for having divided one of them they will all fall out alike) and ſo you ſhall have the 32 rumbes or points of the compaſſe, which you may ſubdivide if you pleaſe into halues and quarters, and draw the lines, and by three or four letters expreſſe their names as in the figure, which ſignifie as followeth.

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Weſt by North	*Eaſt by South*
Weſt	*Eaſt*
Weſt by South	*Eaſt by North*
Weſt-South-weſt	*Eaſt-North-eaſt*
South-weſt by Weſt	*North-eaſt by Eaſt*
South-weſt	*North-eaſt*
South-weſt by South	*North-eaſt by North*
South-South-weſt	*North-North-eaſt*
South by Weſt	*North by Eaſt*

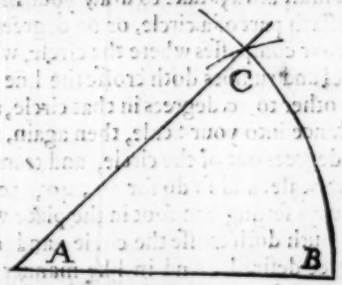
To make an angle of any quantity.

Having thus divided a circle into theſe three ſorts of parts, it will be very uſefull to you in the dividing of any other circle, quadrant, or arch, and by this circle you may eaſily draw any angle of what quantity you pleaſe.

For

For example, let A B be a line given, and it is required to draw another line from the point A, so that it may make an angle of 45 degrees.

First, set one foot of your compasses in the center of your divided circle, and open the other to the circumference of that circle which is divided in to degrees. Then with this distance, set one foot of your compasses in the point A, and with the other draw the arch B C. Then again set one foot of your compasses in that place of your divided circle, where the degrees begin to be numbred, (which is where the line of North and South doth crosse the circle) and open the other to 45 degrees of that circle; and with this distance set one foot in B, and with the other crosse the arch B C in the point C. Then lay your ruler by the point A and the crosse at C, and draw the line A C, so the angle at A made by these two lines A B and A C, wil be 45 degrees, as was required.



Another Example.

In like manner supposing the line A B to be the Meridian or South line, and it is required to draw a line from the point A, which shal represent the Southeast or the fourth Rumbe from the Meridian.

First, set one foot of your compasses in the center of your divided circle, and extend the other to that circle which is divided into Rumbes, and with that distance draw the arch B C. Then setting one foot of your Compasses in that point where the South line and the circle crosse each other, open the other to the line of Southeast, and then set off that distance from B to C in this last figure, then draw the line A C which will represent the Southeast as was desired.

To make a Scale of Chords and Rumbs.

You may doe this also by a Scale of degrees, and Rumbes, which you may have upon a straight line on your ruler, which you

you may thus make. Firſt, ſet one foot of your compaſſes in the center of the divided circle, and open the other to that circle, which parts the diviſions of the degrees and rumbes, and ſet off this diſtance on a ſtraight line upon your ruler, and marke very well with ſome ſpeciall marke, where this diſtance begins and ends, for this is your Radius or diſtance, which you muſt always take to draw your firſt arch withall, it being the ſixth part of a circle, or 60 degrees. Then ſetting one foot of your compaſſes where the circle, which is divided into degrees and rumbes doth croſſe the line of North or South, open the other to 10 degrees in that circle, and then transferre that diſtance into your Scale, then again, take out the diſtance of 20 degrees out of the circle, and transferre that likewiſe into your Scale, and ſo do for 30, 40, 50, 70, 80, 90 degrees. Always ſetting one foot in the place where the line of North or South doth croſſe the circle, and opening the other to the degree deſired. And in like manner when you transfer theſe diſtances into your ruler, you muſt always ſet one foot of your compaſſes at the beginning of the line, and with the other mark the diſtance in the line. And thus alſo you may take out the diſtances of the Rumbes, and ſet them upon a line on your ruler, and ſo having made your Scale, you may draw out any angle by it, as well as by the circle, and it will be ſomewhat more ready.

Example. Now if you would draw the foreſaid angle of 45 degrees by this Scale, you muſt firſt ſet one foot of your compaſſes in the beginning of your Scale, and open the other to 60 degrees, which is the *Radius* of your Scale, and therewith draw the firſt arch B C, then ſetting one foot in the beginning of the Scale again, open the other to 45 degrees, and with that diſtance, ſetting one foot in B, croſſe the firſt arch at C, and then draw the line A C, as in the former example and figure.

CHAP.

CHAP. III.

Shewing how to make a plain Chart, and many Propoſitions of ſayling by it.

THe drawing of the plain Chart, and the way of ſailing thereby, is the moſt plain and eaſie of all others. And though it be fit to be uſed, only in places neer the Equinoctial, or in ſhort Voyages: yet it will ſerve, for a good introduction to that which follows, and this will not be loſt labour, for the ſame kind of work (with ſome cautions) muſt be obſerved in all kinds of Sailing.

The deſcription and making of the plain Chart.

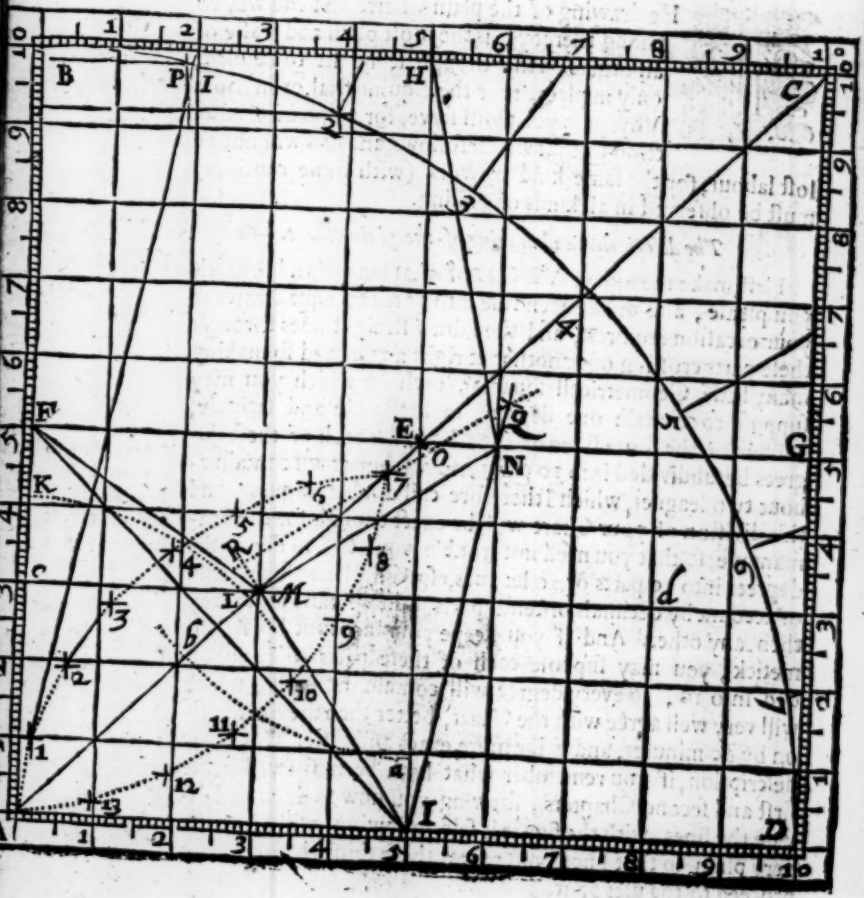
The deſcription of the plain Chart.

Firſt, make the ſquare A B C D of what length, and breadth you pleaſe, and divide each ſide into as many equall parts as your occaſion requires, and then draw ſtraight lines through theſe parts croſſing one another at right angles, and ſo making many little Geometricall ſquares, each of which you may ſuppoſe to contain one degree, in longitude and latitude, * Then on the foure ſides of the Chart, let each of theſe degrees be ſubdivided into 10 parts, ſo each part wil contain about two leagues, which I therefore call double leagues. And this diviſion of your Chart will be exact enough for the Seamans uſe, ſo that you need not trouble your ſelf to divide the degrees into 20 parts or 20 leagues, eſpecially becauſe this way of account by decimals or tenth parts, is more eaſie and ready then any other. And if you keepe your account by Arithmetick, you may ſuppoſe each of theſe parts to be ſubdided into 10, ſo every degree will contain 100 parts, which will very well agree with the Chart, better then the old diviſion by 60 minutes, and is far more exact and eaſie. This ſhort deſcription, if you remember what hath been ſhewed in the firſt and ſecond Chapters, ſhewing you how to draw and divide the lines, with the figure it ſelf following, will I hope be very plain, ſo that I need not repeat thoſe things before, but proceed to the uſes of it.

* According to account 20 Leagues are in one degree, & ſo each 10 part wil be a leagus, but it is ſomwhat more, as you may ſee in the third propoſition of this Chapter.

The

The Figure of the *Plain Chart.*



PROPOSITION I.

Knowing the longitude and latitude of a place, to finde out that very point upon the Chart, and ſo to ſet it upon the Chart.

THe Longitude of places, is their diſtance Eaſt and Weſt. The latitude of places, is their diſtance North and South. In the Globe, the longitude of places is accounted always from the Weſt, Eaſtward; ſtill increaſing the number of degrees, untill they come to 360, which is the whole compaſſe of the Globe, ſo that you come to the firſt Meridian againe. This account of the Longitude may begin at any place, but Geographers do commonly begin to reckon it from one of the Iſles of the *Azores*. But it is the beſt way for the Seamen, not much to regard this, but to reckon by the difference of longitude, or (which is all one) by the difference of the Meridians of the two places. The latitude of places is reckond by their diſtance from the Equinoctial toward either of the Poles, ſo that it never exceeds 90 degrees. If the place lye between the Equinoctiall and the North pole, it is ſaid to have North latitude. If it lye between the Equinoctiall, and the South Pole, it is ſaid to have South latitude. Now though in ſome propoſitions, the Seaman reckons by the difference of latitude, yet in moſt of his accounts and obſervations he doth reckon the latitude of places by their true diſtance from the Equinoctiall North or South.

What the longitude and latitude of a place is.

Now for example of the Propoſition. Suppoſe a place to have 5 degrees of Longitude from the firſt meridian Eaſtward and to have five degrees of north latitude, and it is required to finde out the point, where this place muſt be ſet upon the Chart.

By the longitude and latitude of a place to finde the point thereof upon the Chart.

To perform this you muſt ſuppoſe the line A B in the Chart to be the firſt Meridian, and becauſe the place propoſed is 5 degrees from it to the Eaſtwards, therefore you muſt count 5 degrees from the line A B both in the top and bottome of your Chart, and laying your ruler there, draw the line H E I, then becauſe the place hath 5 degrees of North latitude, you muſt

ſuppoſe the lower line A D to be the Equinoctiall line, and ſo accounting 5 degrees upward in both the ſides of the Chart, lay your ruler there, and draw the line F E G. Now mark where theſe two lines do croſſe one another, which is in the point by E, and this is the point where you muſt ſet the place, or ſuppoſe it to be placed.

PROPOSITION 2.

The longitudes and latitudes of two places being known, to finde the Rumbe, which you muſt ſteere your courſe upon, in ſayling directly between them.

SUppoſe the firſt place to be A, lying under the Equinoctiall, and ſo having no degree of latitude, and likewiſe to be in the firſt Meridian, and ſo to have no degree of longitude. And let the other place be E, which hath 5 degrees of longitude, and 5 degrees of North latitude as before is ſaid, and it is required to find the Rumbe between theſe two places.

By the longitudes and latitudes of two places, to finde the Rumbe.

Firſt, ſet the places A and E upon the Chart, according to their longitudes and latitudes, as is ſhewed before, then laying your ruler by the two places, draw the line A E: this line ſhews the direct way between theſe two places, and if you would know what Rumbe it is, look back to your divided circle, and ſetting one foot of your compaſſes in the center thereof, open the other to the circle of Rumbes, and keeping that diſtance, ſet one foot in the corner A, and with the other draw the arch K L, then ſetting one foot of your compaſſes, in the point where this arch doth croſſe the line A B, which is at K, open the other to L, which is the place where this arch doth croſſe the line A E, and with this diſtance return to your circle, and ſetting one foot of your compaſſes, in the point where the North line doth croſſe the circle of Rumbes, turn the other downward to the circle, the ſame way as it lyes here, and it will point out the fourth Rumbe, which is North-eaſt, and this is the Rumbe you muſt ſail upon, from A to E. In like manner if you would know the Rumbe from E to A, you muſt ſet one foot of your com-

compaſſes in the point E, as you did before in the point A, and draw the arch *a b*, & ſo by your circle of Rumbs you ſhall find that the Rumbe from E to A is South-weſt, which is oppoſite to the North-eaſt. And this is a general rule, look what Rumbe you ſayl upon from one place to another, the Rumbe oppoſed to that, will carry you back again.

You might have found out the Rumbe likewiſe by the Scale of Rumbes, and ſo you would have found it to be the fourth Rumbe from the Meridian, which muſt be either North-eaſt or North-weſt, South-eaſt, or South-weſt, which of the foure it is, you may know by the ſituation of the places when you are a little verſed therein, but till then the Rumbe will be found beſt by the circle.

PROPOSITION 3.

Knowing the Longitude and Latitude of two places, to know how farre they are diſtant one from the other.

3. By the longitude and latitude, to finde the diſtance.

LEt the two places be A and E, whoſe longitude and latitude is as aforeſaid, and it is required to know how farre they are aſunder in ſome known meaſure, *viz.* of miles, leagues, degrees and minutes, or degrees and tenths, or hundred parts.

The beſt way to reckon the diſtance is by tenths.

It is the common practiſe among Seamen to reckon the diſtance of places by leagues, accounting 20 leagues to a degree, and every league to contain about three miles, and ſo each mile to be the 60 part of a degree or one minute. But this way is very troubleſome, and requires often reduction of one ſort of parts to another. The decimall way of account is far more ready and eaſie, and therefore I have divided the degrees on the ſides of the Chart only in to 10 parts which will be exact enough to this purpoſe, each of thoſe parts will contain about two leagues, and therefore I call them double leagues or tenths of a degree If you deſire to be more exact when you uſe your pen you may ſuppoſe each of theſe to be ſubdivided into 10, and ſo make 100 parts in a degree, & then by adding to a cypher, or taking away the laſt figure, they will be reduced one to the other.

Having thus determined the manner of the meaſure, the way to finde the diſtance of the places is thus First, ſet the places upon the Chart according to their longitude and latitude at A and E, then ſetting one foot of your compaſſes in one of the places as A, open the other to E the other place, then meaſure this diſtance in one of the ſides of your Chart, and your compaſſes wil reach from the corner A to * 7 degrees, and one of the tenth parts very neer, and that is the diſtance of the two places, or 71 double leagues or tenth parts, or 710 hundred parts *ferè*.

7,07.

The true quantity of a degree upon the earth.

And here by the way, give me leave to tell you, that it is not enough for you thus to know the diſtances of places in degrees and parts, but it is neceſſary alſo to know, the juſt quantity or meaſure of a degree. And here in the common rule is much out, which accounts 5 foot to a pace, and 1000 ſuch paces, that is 5000 feet to a mile, and 60 ſuch miles, that is 300000 feet to a degree. Neither will the Engliſh mile which is ſomewhat more then this ſerve the turne, whoſe length is thus by the Statute. 16 feet and a half make a pole, 40 poles make a furlong, and 8 furlongs, that is 5280 feet, make a mile: and ſo 60 ſuch miles do contain 316800 feet. But Mr. *Norwood*, by meaſuring the way from *Yorke* to *London* found that a degree doth exactly containe 367200 Engliſh feet, and ſhews how this experiment agrees with former experiments made by others, if rightly conſidered: however his experiment is ſo full and punctuall, that it may well paſſe for currant, rather then any others which differ from it.

See the Seamans Practice

Now by this reckoning, if one degree contain 367200 feet, then the tenth part of a degree doth contain 36720 feet, and the hundreth part of a degree doth contain 3672 feet. Thus you ſhall know the true diſtance of places, knowing how many degrees and parts they are aſunder.

How your log-line ought to be marked,

And the knowledge hereof is very conſiderable in the keeping of your dead reckoning by the Log-line, which you ſhall doe well to rectifie according to this experiment thus. If you keep your account by an half minute glaſſe, then at every 30 feet length of your line, you muſt make a knot: and then ſo ma-

many of thoſe knots as you veer out in half a minute, ſo many 100 parts of a degree the ſhip runs in an hour. As if you veer but one knot while the halfe minute glaſſe is running, then the ſhip runs but $\frac{1}{100}$, that is one hundreth part of a degree in an hower, if you veer 2 knots, then the ſhip runs $\frac{2}{100}$ parts of a degree, and ſo if you veer 10 of thoſe knots in half a minute, then the ſhip runs $\frac{10}{100}$ or one tenth part of a degree in an hour. If the glaſſe be out not juſt at a knot, then for every 3 feet from the laſt knot you may count a tenth part of an hundreth part more.

And though by this reckoning there be but 360000 feet, allowed to a degree, whereas there ſhould be 367200, theſe 7200 feet are thought fit to be abated, not onely in regard of the rotundity of the number, to avoid fractions but for theſe conſiderations. Firſt, becauſe though he that veers the line be never ſo careful not to over-hale it, yet the log will be drawn thereby ſomewhat after the ſhip. Secondly, the Eddy which the ſhip makes, is ſubject to draw the log ſomewhat after it; or at leaſt ſo to dead the water, that it will ſomewhat hinder the motion of the log. Thirdly, the wind and waves beating after the ſhip will drive the log ſomewhat forwarder then it ſhould be. For theſe cauſes, the way of the ſhip may very well be ſomewhat more then the log line ſhews for. Beſides if this were not ſo, yet it is the beſt way to have your reckoning run ſomewhat before your ſhip, that ſo you may not fall upon a place before you are aware of it.

Proposition 4.

Knowing the longitude and latitude of the place from whence you came; the Rumbe you have ſailed upon; and how farre you have ſayled there on: to know the longitude and latitude of the place where you are, at that preſent.

4. By the Rumbe and diſtance, to finde the difference of longitude and latitude.

Let the place from whence you have ſailed be A, whoſe longitude and latitude ſuppoſe to be as aforeſaid, 00 deg. let the rumbe upon which you have ſayled be Northeaſt, and let the diſtance which you have ſayled upon this rumbe from

7,07. from the place A, be almoſt * 71 double leagues, or tenths of a degree. Now it is required, to know what place you are now in, that is, what longitude and latitude you are come to.

To performe this firſt ſet down the place A according to his longitude and latitude, then by your circle or ſcale of Rumbes, draw the line A L E C which is Northeaſt from the point A, then ſetting one foot of your compaſſes in the beginning of your ſcale, which is on the ſides of your chart, open the other almoſt to 71 double leagues, that is to * 7 deg.
7,07. and one tenth part almoſt, and with this diſtance ſet one foot in the point A, and with the other croſſe the line A L E C in the point E. This croſſe at E is the place where you are now, and if you would know the latitude & longitude of this place, then lay your ruler (or rather a ſmall thred) to the point E, ſo that it may cut the ſcale of degrees, on both ſides the Chart at like parts, as the line F E G doth, which you ſee cuts the ſcale at juſt 5 degrees on each ſide, which ſhews the latitude of the place E to be 5 degrees North from the Equinoctiall. So likewiſe to finde out the longitude of the place, lay the thred by the point E, and like parts of the ſcale of longitude, both at the top and bottome of the Chart, as the line H E I doth, and it will ſhew that the longitude of the place is juſt 5 degrees. So that the place where you now are which is E, hath 5 deg, of north latitude, and 5 deg. of longitude.

Note. How to keep your dead reckoning upon the Chart.

This is the way whereby you may beſt keep your dead reckoning upon your Chart. For the Seaman alwayes knowes what point of his compaſſe he ſails upon, and alſo by the log-line, or by experience, he may gueſſe very well how far his ſhip goes in an hour, and by that, for any other time, which diſtance being thus ſet upon the Rumbe line in the Chart, ſhews him ſtill whereabouts he is. And it will be very good, at all times to keep this dead reckoning as carefully as you can, yea, though you ſayle neer the meridian, and ſo have no need of it for the preſent, yet then you may the better ſee how your dead reckoning agrees with your obſervations, and ſo gaine experience to keep your dead reckoning more truly, in ſuch courſes, and againſt ſuch times, as you ſhall have more need of it.

For

For ſome times it may be cloſe weather, for 3 or 4 dayes together, and in courſes that lye neer the Eaſt and Weſt, you will be forced to ſticke to your dead reckoning, having no helpe to rectifie it by the obſervation of the latitude.

Proposition 5.

Knowing the longitude and latitude of the place, from whence you ſet ſayl: together with the Rumbe you have ſayled upon; and by obſervation knowing the latitude of the place you are in: to know thereby the longitude of this place, and how farre it is diſtant from the place you came.

LEt the place from whence you ſet ſail be A, whoſe longitude and latitude ſuppoſe to be as before; let the Rumbe upon which you have ſailed be North-eaſt; and let the latitude of the place where you are, according to your obſervation be 5 degrees of North latitude. Now it is required to finde out the longitude of this place, and how it is diſtant from the place at A.

5. By the Rumbe and the difference of latitude, to finde the difference of the longitude and the diſtance.

To performe this, firſt ſet downe the place A in your chart, according to its longitude and latitude, and draw the line A L E C which is the Northeaſt Rumbe from the point A, as is before ſhewed. Then becauſe by your obſervation you finde your ſelfe to be in 5 deg. of North-latitude, count 5 degrees on both the ſides of your Chart, and laying your ruler thereto, draw the line F E G. Now marke well, where this line doth croſſe the line of the Rumbe A L E C, which is in the point E: for this point is the place where you are at the time of this obſervation. Now to know the longitude of this place, lay your ruler or a thred by the croſſe at E, ſo that it may cut like parts of the degrees of longitude, both at the top and bottome of your Chart, ſo you ſhall draw the line H E I, which ſhews that the longitude of the place is 5 degrees. Laſtly, to finde the diſtance of this place from A, ſet one foot of your compaſſes in A, and open the other to E, and meaſure this diſtance in your ſcale, you ſhall finde it to be 71 double leagues, or 7 deg. one tenth almoſt.

Now

Note. Now this is the moſt certain way that the Seaman can keep his account by, and therefore if there be any difference between your dead reckoning and this: you muſt correct your dead reckoning by this, and not this by that. And therefore it concerneth the Seaman to be very carefull in theſe two things, upon which the ground of this Propoſition depends. Firſt, that the ſhip be ſteered exactly upon the Rumbe ſuppoſed, and to this end, not onely the Steers man muſt be carefull to keep the ſhip to the Rumbe of the compaſſe, which he is appointed, but you muſt be carefull to obſerve the variation of the compaſſe and allow for it. And ſecondly when you make obſervation of the latitude, you muſt do it with true and good large Inſtruments, and uſe the beſt diligence you can in obſerving by them, that ſo you may finde your latitude as exactly as you can.

Proposition 6.

How to rectifie your account, when your dead reckoning differs from your account by obſervation.

6. How to perfect your account.

THis Propoſition hath two caſes, the firſt is when you have kept your way onely upon one point of the compaſſe. The ſecond is when you have been forced to ſayl upon two or more ſeverall points, before you could make any obſervation of the latitude.

Caſe 1. If you have ſayled only upon one Rumbe.

In the firſt of theſe caſes, if you have onely ſayled upon one point of the compaſſe: as for example, ſuppoſe you have ſayled from the point I which lies under the Equinoctiall line in 5 degrees of Longitude; upon the third Rumbe from the Meridian *N W by N*, 40 double leagues, or tenths according to your dead reckoning: if you ſet this upon the Chart according to the Rules before ſhewed, according to this your dead reckoning you will finde your ſelf to be in the point R, which is in 2 deg. $\frac{8}{10}$ of longitude, & in 3 deg. $\frac{3}{10}$ of latitude. But at this time ſuppoſe by obſervation, you finde that you are but juſt in 3 degr. of North latitude. Wherefore to finde the true place where you are, do thus.

First,

Firſt, lay your Ruler, to 3 deg. of latitude on both the ſides of your Chart, and draw the line *c* M *d*, and marke where it doth croſſe the line of the Rumbe I R, which is at M, and this is the place where you muſt reckon your ſelfe to be at the time of your obſervation, and not at R, as you ſuppoſed by your dead reckoning. Now if you examine the longitude and latitude of this place M by the former rules, you will find that it lyes in 3 degr. of longitude, and in 5 deg. of north latitude, and from this place you muſt ſet off your next courſe, and diſtance, and not from R.

Caſe 2. When you have ſailed upon divers Rumbes.

But now for the ſecond caſe. If it ſo happen, that you are forced to ſayl upon two or more ſeverall points of the compaſſe, before you can make an obſervation of the latitude to correct your dead reckoning by. As ſuppoſe you had ſayled according to your dead reckoning, firſt *N W by N*, 40 double leagues, which is ſet down from I to R, (though in truth you had ſailed but from I to M; which is but 36 double leagues) and then being forced to ſhift your courſe to *N E by E*, and ſhould ſail upon this rumbe likewiſe according to your dead reckoning 40 double leagues, and at this inſtant time, you finde by obſervation that you are but in 5 degrees of north latitude: to know the true longitude of this place, you muſt doe thus.

Firſt, from the point I, ſet the firſt 40 double leagues upon the Rumbe *N W by N*, which will end at R. Then from the point R draw the rumbe *N E by E*, which is the line R Q, and ſet thereon the 40 double leagues from R to Q: thus you will finde Q to be the place you ſhould be in, according to your dead reckoning which is in 5 d. $\frac{5}{10}$ and ſomewhat * more of north latitude, whereas by your obſervation you finde that you are but in 5 deg. of north latitude: now to know the true place where you are, in reſpect of the longitude, becauſe you have ſayled upon two rumbes, draw the line I Q from I, the firſt place you ſet ſayl from, to Q, the place of your dead reckoning, and then drawing the line F E G at 5 deg. of latitude according to your obſervation of the latitude; marke where it croſſeth this line I Q, which is in the point N, and this is the

* 5d. 55.

true place you are in, whoſe longitude is 6 deg. and whoſe latitude is 5 deg. north. In like manner, if you ſhould ſail upon 3 or 4 ſeverall Rumbes before you can make an obſervation of the Latitude, your beſt way will be to draw a line from the firſt place of your voyage to that preſent place according to your dead reckoning; or at leaſt from the laſt place, where you made a fair obſervation, and are thereby well aſſured both of the longitude and latitude thereof: For otherwiſe you may be much miſtaken in the longitude of your places.

As for inſtance, if in the laſt example, you ſhould thinke you were in that place, where the line of latitude F E G doth cut the laſt rumbe you ſayled upon, according to your dead reckoning, *viz.* the line R Q, by this account you would be but in O, which is but in 5 deg. $\frac{15}{100}$ of longitude, whereas you ſee by the other way which is the truth, you are in 6 deg. of longitude, ſo that the difference is $\frac{45}{100}$. which is very conſiderable in ſo ſmall a ſpace.

PROPOSITION 7.

Being to ſayl from one place to another, but by reaſon of croſſe winds, or the coaſtings of the land, you cannot ſail thither upon the direct point of the compaſſe which lies between the two places, but are forced to alter your courſe ſeverall times: yet how you ſhould keep your account of your way, ſo that you may know at any time what longitude and latitude you are in, and how the place you are bound to bears from you, and how farr you want to it.

7. The manner of keeping your reckoning upon the Chart.

FOr example, ſuppoſe you were to ſayle from the place I, in the former Chart, which is under the Equinoctiall, and in 5 degrees of longitude; unto the place H, which hath 5 deg. of longitude, and 10 degrees of north latitude: here the direct way from I to H lies full north: But ſuppoſing that you cannot ſail upon this point, but are forced firſt to run *N W by N* 36 double leagues, and then *N E by E* 36 doubled leagues more, the queſtion is what is the longitude and latitude of this place, and how farre it is diſtant from the place H, and upon what point of the compaſſe it lyes from it.

This Propoſition contains the uſe and practiſe of all the former.

First,

Firſt, from the point I, draw the Rumbe *N W by N*, and ſet off theron 36 double leagues from I to M. Then from this point M draw the Rumbe *N E by E*, and ſet off thereon the 36 double leagues which you have ſayled upon it, from M to N: thus you ſhall finde, that N is the place wherein you are, whoſe longitude is ſix degrees, and whoſe latitude is five degrees. Now if you lay a ruler from this point N, to the place you are bound, to which is H, and draw the line H N, this line is the direct way to the place you are bound, and by the help your circle or ſcale of Rumbes, you ſhall finde that it lyes *North by Weſt*, or the firſt Rumbe from the meridian Weſtward. Laſtly, if you ſet one end of your compaſſes in N, and open the other to H, and meaſure that diſtance in the ſides of the Charts, you will finde it to be about 5 degrees $\frac{1}{10}$, or 51 double leagues, and ſo much you want to the end of your voyage.

PROPOSITION 8.

How to know the diſtance of any Cape, Headland, *or* Iſland, *from you, which you can ſee at two diſtant places.*

8. To know the diſtance of any Cape from you

SUppoſe that ſayling on the Sea, you eſpie an Iſland or Cape lying at the firſt ſight, juſt *North-eaſt* from you; and then ſayling forward upon your way, which lies full North, to the diſtance of 5 leagues, you then obſerve that the Iſland lies full Eaſt from you, the queſtion is to know the diſtance of this Iſle from either of theſe two places.

In ſuch queſtions as this, you may ſuppoſe each degree in the former Chart to ſtand now but for a league, and let the firſt place where you eſpied the Iſland be at A, now becauſe the Iſland lay *North-eaſt*, from this place, draw the line A E which is *N E* from A. Then count the 5 leagues which you have ſayled upon your courſe which was full north, in the meridian line from A to F, and becauſe from this place, the Iſland did lye full Eaſt, therefore from this point F, draw the Eaſt line F E G, and marke where this line doth croſſe the former line A E of *N E* from A, which is in the point E. This therefore muſt needs be the place of the Iſland, whoſe diſtance if

These two following Propoſitions rather belong to the plain table then the chart.

you take with your compasses, and measure in the sides of the Chart, you shall finde that the place E is distant from A 7 leagues and almost $\frac{1}{10}$ part of a league; and from F just 5 leagues.* And by this means if you know the longitude and latitude of this Isle or Cape, you may the more certainly know the truth of your account, and if need be correct it. Or if you knew not the place before, you may set it down in your chart by its longitude and latitude which you finde it to be in, according to the best account you can make by your observation.

*A double use of this proposition.

Proposition 9.

By observing upon what Rumbes many places lye from you at two severall stations; to finde the distances of those places, and their true posture and bearing one from another.

9. To finde out the true distance, and bearing of many places. The use of this Proposition.

As in the former Proposition you did for one place, so in this you may do for many. And this will be of good use, for hereby, sayling in sight of any Coast, you may finde out how the Points and Rivers and such like lye, and so make a Map thereof. The way to perform which is thus. First, observe well how the severall places lie from your first station, which suppose to be A; and let these three places be observed by you *viz.* I M and E. I bears from A full East, M and E, North-east, therefore draw the lines A I and A M E according to the bearing of the places from A. Secondly, you must observe your course which you sail upon, untill you come to the second station, which suppose to be five leagues full North, let this be set down according to its place at F. Thirdly, this being your second station, observe how the three former places bear from this place, and suppose you find, that E lyes full east from this place, M lyes South-east by east, and I lyes South-east, from this second station. Then draw these lines F E, F M, F I, from the point F, and mark well where they crosse the former lines, which will be in the said points E M and I, and thus these three places E M I are set down according to their true positions and distances, both from the two stations A and F, and likewise one from another, so that if you try by the former

mer rules, and your comaſſes you ſhall finde M lyes from I, *N W b N* 3 leagues and $\frac{6}{10}$, and E lyes from M, *N E*, 2 leagues and $\frac{8}{10}$. Thus you may eaſily deſcribe the coaſt of a Country as you ſayle by it in ſight of it, which will be both pleaſant and profitable, eſpecially when you light upon Coaſts that have not been diſcovered.

PROPOSITION 10.

To draw a Rumbe line from any point aſſigned.

10. To draw a Rumbe line from any point in the Chart.

IN this deſcription of the plain Chart, I have purpoſely omitted the old cuſtome, of peſtering the Chart with ſo many Rumbe lines, to little or no purpoſe. For though they may ſeeme to be of ſome uſe in this Propoſition; yet it may better be performed, onely by the lines of longitude and latitude with the help of the circle, or ſcale of Rumbes. For firſt, if your point aſſigned fall out in any of the meridian lines, then you may readily by the rules of the ſecond chapter, *pag.* 13, 14. draw any rumbe line from that point. But if your point do not fall juſt upon, a meridian line, then you muſt, firſt, from the point aſſigned, draw a line parallel to any one of the meridian lines, as is ſhewed by the ſecond propoſition of the firſt chapter, and then draw the Rumbe line from your point aſſigned in that line, as you did before. Thus you ſee theſe lines of longitude and latitude are of double uſe. For firſt, they readily ſhew you the longitude and latitude of any place in ſome meaſure by the eye. And then they help in the drawing rumbe lines, from any point. Whereas to draw ſo many rumbes after the uſuall manner, is but a ſpending much time and labour to little purpoſe.

CHAP.

CHAP. IIII.

Shewing how to make a Sea-chart for any part of the World, which ſhall agree in all particulars with the Globe; with ſeverall Propoſitions ſhewing the manner of uſing it.

The defects of the plain Chart.

THe way of ſayling by the plain chart, is very eaſie to underſtand, as you may ſee by what hath been ſaid in the former chapter: But it hath this inconvenience, that it is fit to be uſed onely in places neer the Equinoctiall, or in ſome ſhort voyages. For it ſuppoſeth the degrees of Longitude to be all of one length, in every Latitude, and therefore it makes the degrees both of longitude and latitude, all of one length and breadth in all places. But you muſt know that though the degrees of Latitude, are alwayes of one and the ſame breadth (*viz.* about twenty leagues) yet the degrees of longitude are not all of this length, but as you may ſee in the Globe, they grow leſſe and leſſe toward the Poles: ſo that though about the Equinoctiall, a degree of longitude is equall to a degree of latitude, *viz.* about 20 leagues: yet in the latitude of 60 deg. one degree of longitude is equall but to half a degree of latitude, *viz.* about 10 leagues; and about the latitude of 75 deg. 30′, one degree of longitude is equall but to a quarter of a degree of latitude, which is about 5 leagues. And therefore it is impoſſible to ſet three places upon the plain chart, which differ one in longitude and latitude, as they ought to be placed, that is according to their places on the Globe. But if you ſet them down, according to their longitudes and latitudes; then they will not ſtand in their true Rumbes and Diſtances one from the other: and if you ſtrive to ſet them down according to their Rumbes and Diſtances; then their Longitudes and Latitudes will not fall out right.

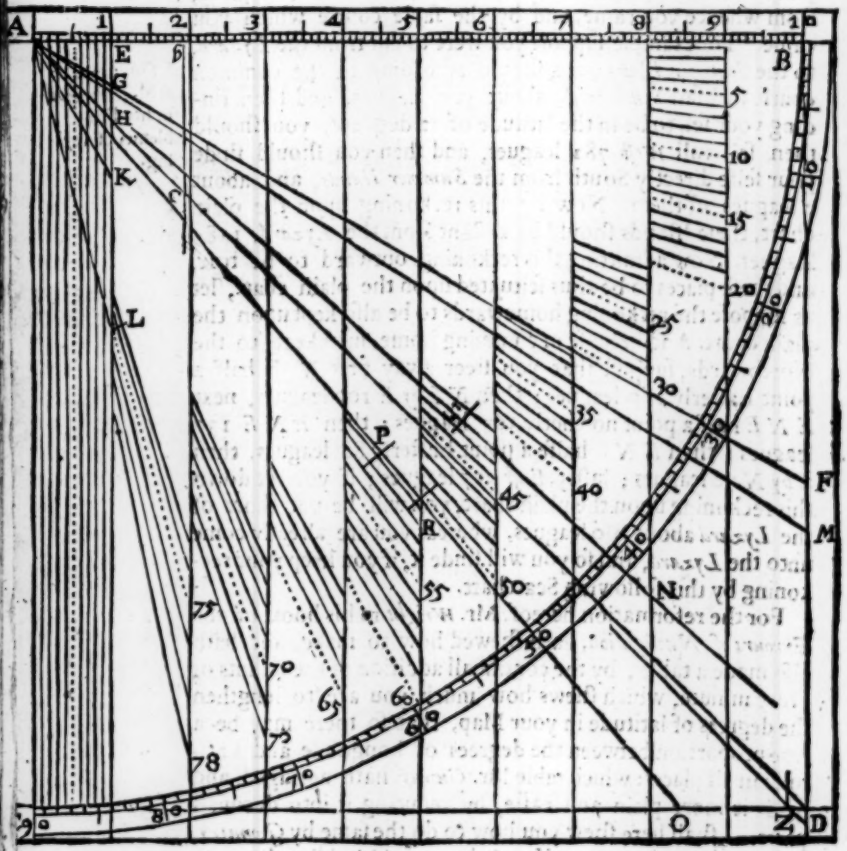
And

And therefore though you may make a ſhift to performe ſome ſhort voyages by it, yet you cannot uſe it in any long voyage without great errour: except you onely goe from one place to another, and ſo directly back again to the ſame place, from whence you came, and by the ſame courſe which you came. * For example, ſuppoſe you were to ſail from the *Lyzard*, to the *Summer Iſlands*, and ſhould according to the common courſe firſt ſail *South-weſt*, about 500 leagues, and then finding your ſelf to be in the latitude of 32 deg. 20′, you ſhould then ſail full *Weſt* 782 leagues, and then you ſhould finde your ſelfe directly South from the *Summer Ilands*, and about 2 leagues off them. Now by this reckoning upon the plain chart, theſe Iſlands ſhould be diſtant from the *Lyzard*, 1189 leagues. Now admitting this reckoning outward to be true, and theſe places to be thus ſcituated upon the plain chart, let us ſuppoſe the reckoning homewards to be alſo kept upon the plain chart. And becauſe in comming home, men keep to the Northwards, ſuppoſe that you ſteer away firſt *N E* half a point Eaſterly 200 leagues; then *N E by E* 100 leagues, next *E N E* half a point northerly 165 leagues; then *E N E* 130 leagues; then *E N E* halfe a point Eaſterly 88 leagues, then *E by N* 70 leagues; laſtly, *Eaſt* 317 leagues; if you ſet down this reckoning upon the plain chart, you will be yet ſhort of the *Lyzard* about 160 leagues, whereas you are already come unto the *Lyzard*, and ſo you will finde it, if you keep your reckoning by this following Sea-chart.

*This example is M. *Norwoods* in his Problemes of ſayling.

For the reformation hereof, Mr. *Wright* in his book of the *Errours of Navigation*, hath ſhewed how to make, and hath alſo made a table, by the continuall addition of the ſecants of every minute, which ſhews how much you are to lengthen the degrees of latitude in your Map, that ſo there may be a true proportion between the degrees of Longitude and Latitude in all places: which table Mr. *Gunter* hath abridged, and made it more plain and eaſie, by reducing it into decimall parts. I ſhall here ſhew you how to do the ſame by *Geometry*, and how to make a line of Latitudes, or a Meridian line anſwerable to any line of longitudes.

First,


A
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75
78

The projection of the Meridian Line.

First, make the Quadrants A B C of what largnes you pleaſe, and divide the limbe thereof into 90 degrees numbring them from B towards C, then divide the ſide of the Quadrant A B into 10 equall parts, and draw ſtraight lines from them parallel to A C, then take one of theſe parts from A to E, and ſubdivide it into 10 leſſer parts, and draw lines from them parallel unto A C. Now you muſt note that the length of this one part A C is to be your radius, or the meaſure of one degree of longitude in your Chart, ſo that the whole line A B will be 10 degrees, and becauſe theſe degrees of longitude are to be of one length in all latitudes, therefore the degrees of latitude muſt increaſe as the ſecants of the latitudes increaſe. Therefore if you would know how long one degree of latitude muſt be in the latitude of 30 deg. lay your ruler to the center A, and the arch of the quadrant at 30 deg. and draw the line A G, now the radius being A E, this line A G is the ſecant of 30 deg. to that radius, and muſt be the length of one degree of latitude in a Chart for that latitude. So likewiſe the line A H which is the ſecant of 45 deg. to that radius, muſt be the length of one degree of latitude, in the latitude of 45 deg. and ſo for any other latitude: and note that the 10 intermediate lines may ſerve to divide each of theſe degrees into 10 parts.

The proof of of this projection.

If you would examine the truth of this projection how it agrees with the Globe; whereas in the Globe one degree of latitude is equall to two degrees of longitude in the latitude of 60 deg: ſo here A K the ſecant of 60 deg. is twice the length of A E the meaſure of one degree of longitude, and whereas in the Globe one degree of latitude is equall to foure degrees of longitude in the latitude of 75 deg. 30′: ſo here A L the ſecant of 75 deg. 30′ is four times the length of A E, and ſo the proportion will hold in any other latitude.

To make a Table of the Meridian line.

If you deſire to make a table hereof, then you may make the whole line A B to be your radius, or the length of one degree, which you may divide into 100 parts, and then the ſecants will be the lines drawn from the center A to the line B D, thus then the line A I will be the ſecant of 30 degrees,

whoſe length is 115, as you may meaſure in the ſcale A B if it were increaſed. And ſo the line A D is the ſecant of 45 degr. whoſe length is 141.* And note here if you make the table for whole degrees only, then it wil be the beſt way to draw the Secant line through the midſt of the degree, as if you would know the length of the line which muſt reach from 29 degrees to 30 degrees, draw the line through 29 degrees 30 minutes, the length wherof will be 115, and ſo by the continuall addition of theſe Secants you may make the Table following, which you ſhall finde agrees very well with Maſter *Gunters*, only his radius is divided into 1000 parts and this but into 100.

Note.

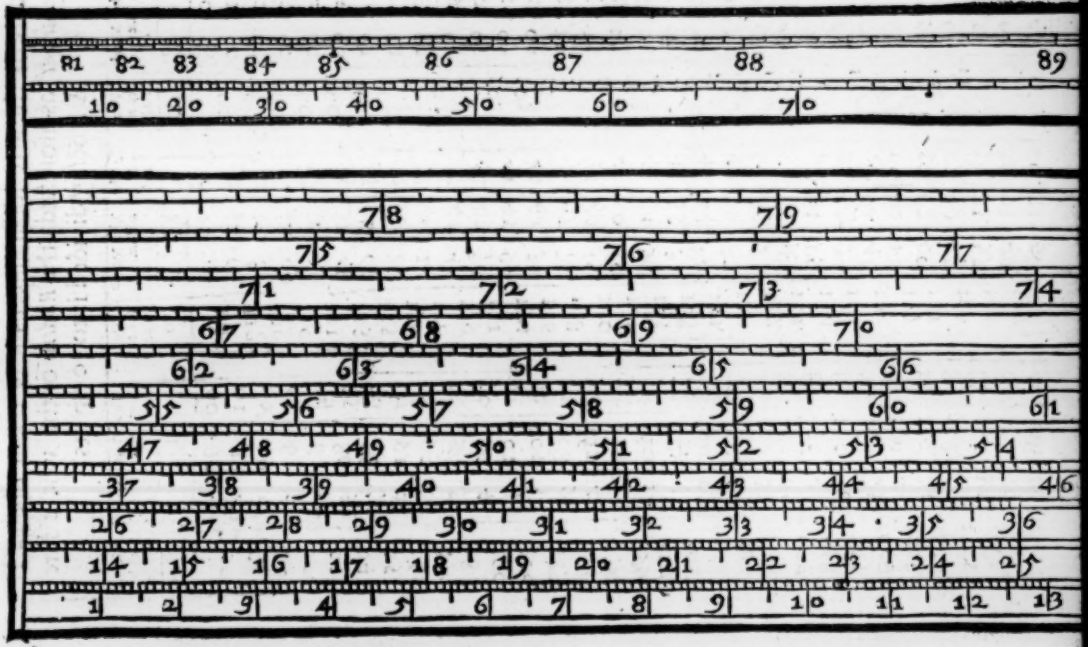
Alſo by the Quadrant, or the Table, you may make the two Meridian lines following. But if you make them by the Quadrant, then becauſe the degrees would fall too cloſe together if they were all drawn, under the firſt Radius A E, you may remove the Radius A E further from the center, and then draw them under it. As for example, the diſtance between the lines 8 and 9 being equall to the diſtance A E, you may there draw the firſt 20 degrees. Then between the lines 7 and 8 being of the like diſtance, draw the next ten degrees which is to 30, and ſo do the reſt as you ſee in the Quadrant. Then taking out theſe degrees one by one with your compaſſes, ſet them upon the Meridian line, of your Chart, or make a Meridian line, at your leaſure, as in the following figure, which will be very ready upon any occaſion.

*Another way to make a Meridian line.

A Table of the Meridian line, as it is taken out of the *Quadrant*, as aforeſaid, the *Radius* or the whole line A B being divided into 100 parts.

The Latitude	The Meridian line		The Sec. to be ad.	The Latitude	The Meridian line.		The Sec. to be ad.	The Latitude	The Meridian line		The Sec. to be added
D.	D.	P.	P.		D.	P.	P.		D.	P.	Parts
0	0	00	100	30	31	47	116	60	75	46	203
1	1	00	100	31	32	63	117	61	77	49	209
2	2	00	100	32	33	80	119	62	79	58	217
3	3	00	100	33	34	99	120	63	81	75	224
4	4	00	100	34	36	19	121	64	83	99	232
5	5	00	101	35	37	40	123	65	86	31	241
6	6	01	101	36	38	63	125	66	88	72	251
7	7	02	101	37	39	88	126	67	91	23	262
8	8	03	101	38	41	14	128	68	93	85	273
9	9	04	101	39	42	42	129	69	96	58	285
10	10	05	102	40	43	71	131	70	99	43	300
11	11	07	102	41	45	02	134	71	102	43	315
12	12	09	102	42	46	36	136	72	105	58	333
13	13	11	103	43	47	72	138	73	108	91	352
14	14	14	103	44	49	10	140	74	112	43	374
15	15	17	104	45	50	50	143	75	116	17	399
16	16	21	104	46	51	93	145	76	120	16	427
17	17	25	105	47	53	38	148	77	124	45	462
18	18	30	106	48	54	86	151	78	129	07	502
19	19	36	106	49	56	37	154	79	134	09	549
20	20	42	107	50	57	91	157	80	139	58	607
21	21	49	107	51	59	48	161	81	145	65	677
22	22	56	108	52	61	09	164	82	152	42	768
23	23	64	109	53	62	73	168	83	160	10	885
24	24	73	110	54	64	41	172	84	168	95	1040
25	25	83	111	55	66	13	177	85	179	41	1280
26	26	94	112	56	67	90	181	86	192	21	1649
27	28	06	113	57	69	71	186	87	208	70	2325
28	29	19	113	58	71	57	192	88	231	95	3985
29	30	32	115	59	73	49	197	89	271	70	
0	31	47		60	75	46		90	infinite		

The lesser *Meridian Line*, for generall *Maps*.



The long *Meridian Line*, for particular *Maps*.

I have made here two meridian lines. and that for two reaſons. Firſt, becauſe in the larger line after 80 degrees of latitude, the degrees grew ſo large, and increaſed ſo much, that it would be both needleſſe and troubleſome to make any uſe of them: but the chief reaſon is this. Becauſe when you are to goe any long voyage, it wil be needfull for you firſt to make a generall Map of your whole voyage by the leſſer line, whereby you may know the courſe and diſtance thereof in generall: and then to make three or four other charts by the greater line upon which, with your ruler and compaſſes you may ſet down your dayly courſes and diſtances more exactly.

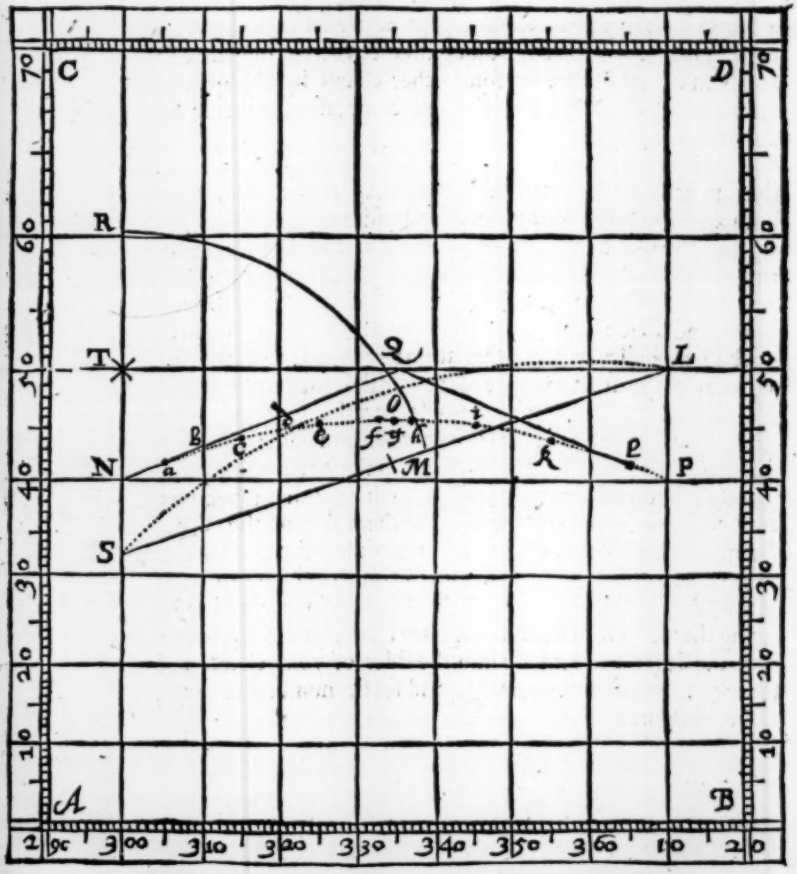
Alſo I have made theſe two lines in ſuch proportion, that the one is the tenth part of the other, that ſo that they may both agree with the ſcale upon the Quadrant.

To make a Sea Chart by theſe Meridian lines.

Now the way to make one of theſe charts is very eaſie, and much after the manner of the plain chart. For firſt, you may draw the line of Eaſt and Weſt A B of what length you pleaſe, and divide it into equall parts or degrees, then you may erect a perpendicular line either at one of the ends of the line. or in any of the diviſions toward the midſt of the line, and then draw the other parallels of longitude parallel thereto, ſo far it is all one with the plain chart, but when you come to draw the parallels of latitude, you muſt not make them all equall, (though they muſt be all parallel) each to other; but you muſt either with your compaſſes, take them out of the Quadrant, or which is more eaſie, lay a ſcroule of paper to the Meridian line which is ready drawn to your hand, and ſo mark out the degrees of latitude upon the ſcroule of paper, and then laying that ſcroule to the ſides of your chart, you may tranſferre the degrees of latitude into the ſides of your chart, and through them draw the parallels, and ſet fit numbers to them, as in the figure.

The figure of a generall Sea-Chart, containing almoſt an eighth part of the Globe.

NORTH.



The ÆQUINOCTIALL line.

Now though this be not a general chart of the whole globe, yet it may be called a generall chart in reſpect of others, which wil ſerve onely for a leſſer portion of the Globe. For this chart containeth almoſt an eighth part of the Globe, and may be fitted to ſet forth any part thereof. For if you change the numbers of the longitude, if the latitude be northward, it wil ſerve as it now ſtands: but if the latitude be Southward, you muſt turne the bottome upward. If you have occaſion in one chart, to ſet down both North and South latitude: then you muſt draw the like parallels of latitude below the Equinoctial, as theſe are above it.

Now I wil ſhew you how the ſeveral Propoſitions which were performed by the plain chart, may be performed by this, and wherein they agree, and wherein they differ.

PROPOSITION 1.

Knowing the longitude and latitude of any place, to ſet it upon the Chart.

1. By the longitude and latitede, to finde the point of any place in the Chart.

THis muſt be done, as in the plain chart. For firſt laying your ruler by the longitude of the place, you muſt draw a little occult line as neere the latitude of the place as you can gueſs, then laying your ruler to the latitude of the place, croſſe that line you drew before with another little line, and ſo the croſſing of theſe two lines wil ſhew you the point where the place muſt be ſuppoſed to ſtand.

Example.

Thus ſuppoſing the longitude of the *Summer Ilands* to be 300 degrees, and the latitude thereof 32 degrees, 25 minutes, you wil finde that it muſt be ſet at S, upon the chart.

PROPOSITION 2.

The longitudes and latitudes of two places being known, to finde the rumbe which you muſt ſaile upon, to go directly from the one place to the other.

2. By the longitude and latitude of two places to finde the Rumbe.

Example.

SUppoſe the one place to be the *Summer Ilands*, whoſe longitude and latitude we wil ſuppoſe to be as is before ſet down, let

let the other place be the *Lyzard*, whoſe latitude is about 50 deg. and let the longitude thereof be ſuppoſed to be 10 degr. ſo the difference of the longitude of the two places, wil be 70 deg. (as Mr. *Norwood* both in his book of the *Doctrine of Triangles*, and his *Seamans Practice* ſuppoſeth them to be, though as he ſaith in one place, he doth not think them to be ſo far diſtant) and it is required to finde the rumbe.

This Propoſition muſt alſo be performed as in the plain chart. For firſt, the two places muſt be ſet upon the chart, according to their longitudes and latitudes, which will be at S and L, then draw a ſtrait line from S to L, this repreſents the direct way between the two places, now to know what rumbe this is, open your compaſſes to the Radius of your ſcale of rumbes, and ſetting one foot of your compaſſes in S with the other, draw the arch R M, then ſetting one foot of your compaſſes in R, open the other to the croſſing of the line, and the arch at M, and meaſuring that diſtance on your ſcale of chords or Rumbes, ſo ſhall you finde it to be 71 deg. 21 min. or the ſixt rumbe and ſomewhat above a quarter of a rumbe, from the Meridian.

Proposition 3.

3. To meaſure the diſtance of places.

Knowing the longitudes and latitudes of two places to know how farre they are diſtant one from another.

LEt the two places be as is before ſaid S and L, it is required to finde their diſtance.

In the working this Propoſition, there is ſome difference from the plain chart, for whereas there you meaſure the diſtance of places by one and the ſame ſcale of equall parts, here you will have uſe of many ſcales, according to the latitude of the places.

Mr. *Gunter's* way.

Now the ordinary way preſcribed by Mr. *Gunter*, to perform this is thus. Open your compaſſes to the diſtance of the two places; and then ſetting your compaſſes in the Meridian line, ſo that the one point of the compaſſes may ſtand juſt ſo much above the greater latitude, as the other doth below the leſſer latitude, and ſo the degrees between them is the diſtance: this way

way may ſerve for ſmall diſtances as Maſter *Gunter* uſeth it; but in greater diſtances it wil not always hold true; and beſides, it is ſomewhat troubleſome to ſet the compaſſes juſt as much above the one latitude, as below the other.

As in this example, if you take the diſtance S L in your compaſſes, and meaſure it ſo in the Meridian line, it wil reach from about 16 degrees, to about 66 degree and an halfe, that is 16 degrees and an half above 50 degrees, the greater latitude, and 16 degrees and an halfe below 32 degrees, 25 minutes, the leſſer latitude, and ſo the degrees intercepted between the points of the compaſſes are about 50 degrees and a half, whereas the diſtance of the two places is almoſt 55 degrees.

The way to meaſure the diſtances of places which differ in longitude and latitude.

But you ſhall finde the diſtance more exactly, if you doe thus. Firſt, divide the ſpace that is in the meridian line between the two latitudes into two equall parts, which in this Example will fall at 42 degrees, then take with your compaſſes halfe the length of the line L S, which is L M, and ſetting one foot of the compaſſes in 42 degrees, which is the middle point between the two latitudes, you ſhall finde that the other point will reach down to 8 degrees and a halfe, then keeping the one foot ſtill fixed in 42 degrees, turne the other foot upward, and it will reach to 63 degrees and a half; now the degrees of the meridian line between theſe two points are 55, which is the diſtance deſired, which is 5500 double leagues or tenths of a degree, or 1100 leagues. But if this diſtance were to be meaſured in the plain chart, the two places being ſet down therein according to their longitudes and latitudes aforeſaid, their diſtance would be above 72 degrees, which is 340 leagues, more then the truth.

How to meaſure the diſtance of places which differ only in longitude.

If you would meaſure a parallel diſtance, as ſuppoſe the two places were L and T, both in the latitude of 50 degrees, and their difference of Longitude is 70, the way will be to take halfe the diſtance which is L Q, with your compaſſes, and ſetting one foot in 50 degrees of the meridian line, the other foot will reach to 22 degrees and a half downwards, and to 67 degrees and a half upward, and if you count the degrees between

theſe two places, or elſe ſubſtract the leſſer from the greater, you ſhall finde 45 deg. which is the diſtance of the two places.

Another way to meaſure the diſtances of parallel places

Yet this may more readily be performed by the Quadrant, *Page* 32, whereby the meridian line was made.

Firſt, if you would meaſure a parallel diſtance, as for example, ſuppoſe you would meaſure the diſtance of the two places T and L, being both in the latitude of 50 degrees, and their difference of longitude is 70 degrees. Firſt, draw the line A P at 50 degrees in the quadrant, then take the diſtance of the two places T L with your compaſſes, and ſetting one foot in A, the center of the quadrant, with the other foot, croſſe the line A P 50 at P, which is juſt in the midſt between the fourth and fift parallel lines, which are drawn from the ſcale of the quadrant, now becauſe the chart is of the leaſt ſize, therefore you muſt account every of thoſe greater parts, for 10 degrees, and ſo the diſtance will be found to be 45 degrees, as before.

Now to know this exactly, theſe greater parts ſhould each of them be divided with lines into ten parts, as the firſt of them is: or elſe you may make uſe of thoſe lines in the firſt part thus. Having made the mark at P, as before; and ſeeing it doth not fall juſt upon one of the parallel lines you may ſet one foot of your compaſſes on the next parallel line at R, and turning the other towards the center A, it will reach in the line P A to the middle line among the leſſer diagonal lines, which ſhews it lacks 5 degrees of 50, and ſo it is 45 degrees.

To meaſure the diſtance of places which differ both in latitude and longitude.

But if you would meaſure the diſtance of two places which differ both in latitude and longitude, as the two places L and S in the chart, you muſt do thus. Firſt, draw the line AM in the quadrant, *pag.* 32, by the arch of the one latitude 32 degrees 25 minutes, then draw the line A P 50, by the arch of the other latitude, 50 degrees, then in any of the parallel lines, divide the ſpace between theſe two lines A M and A P 50 into two equal parts, which if you do in the eighth parallel, the halfe or midſt wil be at N,, then draw the line A N, which wil be your ſcale to meaſure this diſtance by. Now if you take the diſtance S L in the chart, and ſet it on the line A N in the qua-

quadrant, it will reach from A to S, that is in the midſt between the fift and ſixt parallel lines, ſo that the diſtance is 55 degrees, for every one of theſe parallel lines ſtands for 10 degrees when the chart is drawn by the little meridian line.

PROPOSITION 4.

Knowing the longitude and latitude of the place from whence you came, and the rumbe you have ſayled upon, and how farre you have ſailed on that rumbe: to know the longitude and latitude of the place you are in.

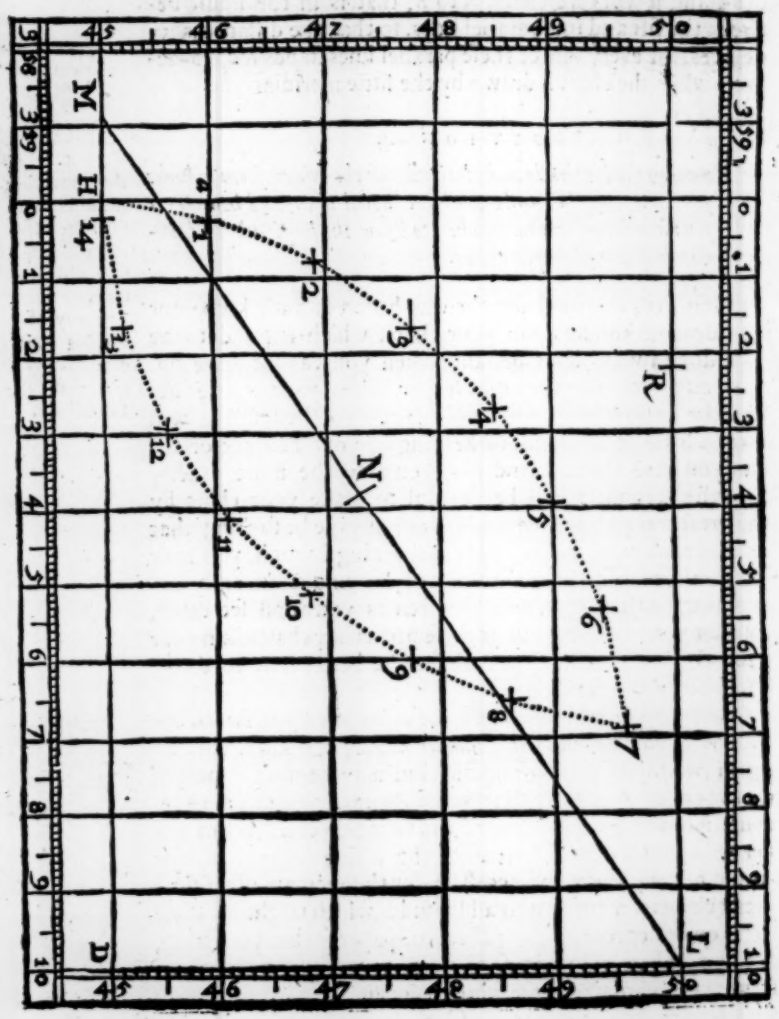
4. By the rumbe and diſtance, to finde the difference of longitude and latitude.

THis Propoſition ſhews the way how you muſt keep your dead reckoning upon your chart, which is good to be done always, but eſpecially when you cannot have opportunity to obſerve the latitudes, or when your courſe lies neer the Eaſt or Weſt, ſo that obſervation of the latitude will do you little or no good, in keeping of your account of the way you have ſailed. And that you may the more exactly keep this account, it wil be needful to make your chart by the greater meridian line, and if your voyage be ſo long that one ſheet of paper wil not make a chart big enough, you may put it into two or three ſheets, and keeping your daily accounts upon them, you may as often as you ſhall ſee cauſe, transfer your accounts out of theſe perticularr charts, into your general chart, and ſo you ſhal ſee the better how to direct your courſe in general.

The way of keeping your dead reckoning upon the Sea-Chart.

Thus ſuppoſing the voyage to be as is before mentioned between the *Lyzard* and the *Summer Ilands*, the chart following drawn by the greater meridian line may contain a part of that voyage. And though this chart being ſtraitned for room contain but a very little part of the voyage, yet a ſheet of paper wil contain one third part of the whole voyage, and it would be very ready and neceſſary for the Seamans uſe, if ſuch blank charts were drawn to all latitudes, which might be done to 70 or 80 degrees in 4 or 5 ſheets of paper ſo that by ſetting, fitting numbers of longitude to them, you might make them ſerve for moſt places in the whole World.

Example.


M
H
R
N
L
D
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12
13
14

Having provided the blank chart, let the example to explain the Propoſition be this. *Having ſayled from the Lizard, about the diſtance of 5 degrees, or 50 tenths on the fift Rumbe from the Meridian S W b W. I would know what longitude and latitude I am come into.*

Now to perform this, firſt you muſt ſet the *Lizard* according to its longitude and latitude aforeſaid upon the chart at L, then from L draw the line L M which is the rumbe you have ſailed upon, then take five degrees which is the diſtance you have ſailed, out of the meridian line; upon the ſide of your chart from 50 to 45, and ſet it from L to N, ſo the croſſe at N ſhal repreſent the place where you are, which you may readily ſee by the Map, to be about 47 degrees and $\frac{3}{10}$ of latitude, and about 3 degrees $\frac{8}{10}$ of longitnde, that is 6 degrees $\frac{3}{10}$ of longitude, diſtant from the Meridian of L. But if you ſhould keep your account by the plain chart you would reckon your ſelfe but 4 degrees, $\frac{3}{10}$ of Longitude diſtant from the place L.

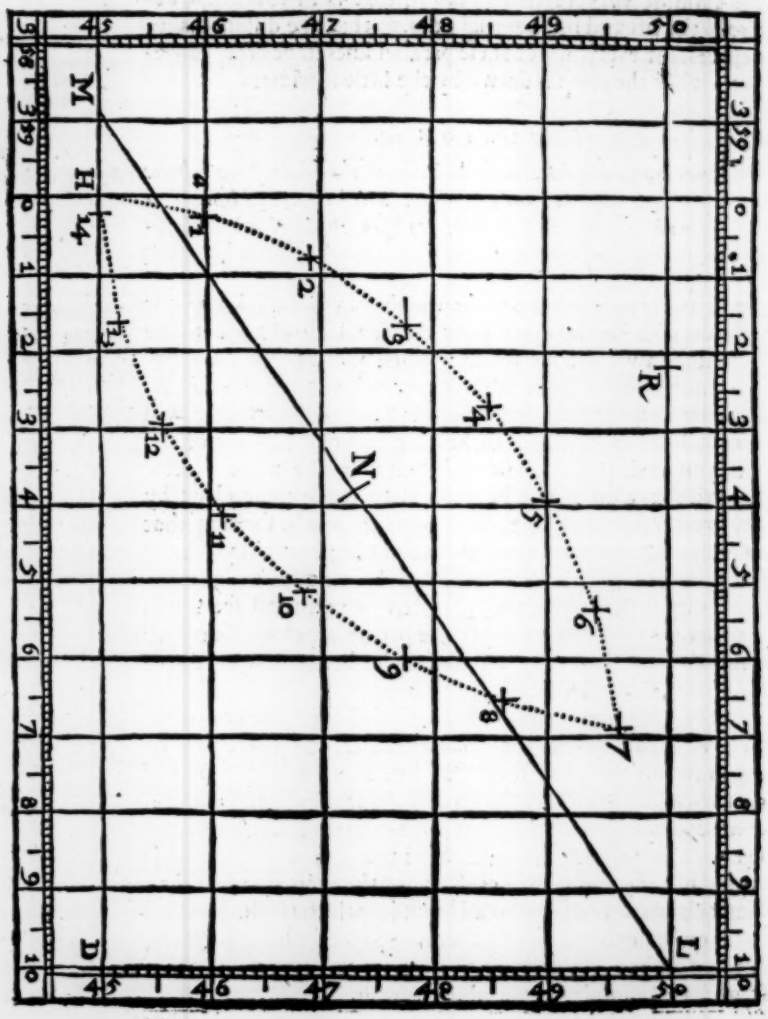
Latitude 50d. Longitude 10d

And though this way there may be ſome ſmal miſtake, ſometimes in over, ſometimes in under reckoning, if you be not very careful to take your diſtance out of the meridian line, as neer the latitudes as you can, yet if the diſtance be not great, and eſpecially if the Rumbe be not far from the Meridian, your errour wil not be much. And you may the leſſe regard it, becauſe this being but your dead reckoning, you need not truſt to it, but may correct it afterward, when you have opportunity to obſerve the latitude.

But when your courſe lies neer the Eaſt and Weſt, ſo that you are forced to truſt to your dead reckoning, becauſe you cannot correct it by obſervation of the latitude, then it wil be the more needful, for you to be the more exact in ſetting off your diſtance, which you may doe by the Quadrant: as for example, ſuppoſe you have ſayled the diſtance of 5 degrees, or 50 tenths ful Weſt from L, and would know what longitude you are then in.

Example of a parallel courſe

Firſt, draw the line A R O in the Quadrant *pag.* 32, by the arch of 50 deg, which is the parallel latitude you have ſailed in


M
H
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12

Having provided the blank chart, let the example to explain the Propoſition be this. *Having ſayled from the Lizard, about the diſtance of 5 degrees, or 50 tenths on the fift Rumbe from the Meridian S W b W. I would know what longitude and latitude I am come into.*

Now to perform this, firſt you muſt ſet the *Lizard* according to its longitude and latitude aforeſaid upon the chart at L, then from L draw the line L M which is the rumbe you have ſailed upon, then take five degrees which is the diſtance you have ſailed, out of the meridian line; upon the ſide of your chart from 50 to 45, and ſet it from L to N, ſo the croſſe at N ſhal repreſent the place where you are, which you may readily ſee by the Map, to be about 47 degrees and $\frac{2}{10}$ of latitude, and about 3 degrees $\frac{8}{10}$ of longitnde, that is 6 degrees $\frac{3}{10}$ of longitude, diſtant from the Meridian of L. But if you ſhould keep your account by the plain chart you would reckon your ſelfe but 4 degrees, $\frac{1}{10}$ of Longitude diſtant from the place L.

Latitude 50d. Longitude 10d

And though this way there may be ſome ſmal miſtake, ſometimes in over, ſometimes in under reckoning, if you be not very careful to take your diſtance out of the meridian line, as neer the latitudes as you can, yet if the diſtance be not great, and eſpecially if the Rumbe be not far from the Meridian, your errour wil not be much. And you may the leſſe regard it, becauſe this being but your dead reckoning, you need not truſt to it, but may correct it afterward, when you have opportunity to obſerve the latitude.

Example of a parallel courſe

But when your courſe lies neer the Eaſt and Weſt, ſo that you are forced to truſt to your dead reckoning, becauſe you cannot correct it by obſervation of the latitude, then it wil be the more needful, for you to be the more exact in ſetting off your diſtance, which you may doe by the Quadrant: as for example, ſuppoſe you have ſayled the diſtance of 5 degrees, or 50 tenths ful Weſt from L, and would know what longitude you are then in.

Firſt, draw the line A R O in the Quadrant *pag.* 32, by the arch of 50 deg, which is the parallel latitude you have ſailed in.

in; then becauſe you have ſailed the diſtance of 5 degrees in this latitude, marke where the fifth parallel line in the Quadrant, croſſeth the line A R O, which is at R, therefore take the diſtance A R out of the Quadrant, and transferre it into the chart from L to R, ſo ſhall R be the true point where you are, whoſe longitude you may ſee by the map to be about 2 degrees $\frac{2}{10}$ being diſtant from the Meridian of L 7 degrees $\frac{8}{10}$, whereas by the plain chart you would think your ſelf to be but 5 degrees diſtant.

5. By the Rumbe and difference of latitude to finde the point where you are.

PROPOSITION 5.

Knowing the longitude and latitude of the place from whence you ſet ſail, together with the rumbe you have ſayled upon, and by obſervation knowing the latitude of the place you are in: to know thereby the longitude of this place you are in, and how farre you are diſtant from the place you came.

THis Propoſition is the ſame with the fift propoſition in the uſe of the plain chart, and is performed juſt after the ſame manner, but with far more truth in reſpect of the longitude or difference of meridians. For example, let the place from which you ſet ſail be the *Lyzard*, whoſe longitude and latitude is before ſet down, let the Rumbe upon which you have ſailed be the fifth Rumbe from the meridian S *W by W.* and laſtly, by your obſervation, you finde your ſelf in the latitude of 45 degrees, the longitude and diſtance of this place from L is required.

To performe this. Firſt, having made the foregoiug chart, ſet down the *Lyzard* according to its longitude and latitude at L, then draw the line L M which is the fift Rumbe from the meridian, and laſtly, becauſe you finde your ſelfe to be in the latitude of 45 degrees, lay your ruler to the parallel of 45 in your chart, and draw the line D M. Now the point where this line D M croſſeth the rumbe line L M, is the place which you are then in, whoſe longitude you ſee by the Map is 358 degrees $\frac{9}{10}$: ſo that it differs from the meridian of L. 11 degrees $\frac{1}{10}$. But if you ſhould performe this propoſition upon the

the plain chart, you would account your ſelf to be but 7 deg. and an half from the meridian of L.

Laſtly, if you meaſure the length of the line L M, either by the meridian line on the ſide of the chart, or rather by the Quadrant, as was ſhewed before, you will finde that you have ſayled from L; 9 degrees, or 90 tenth.

Thus you ſee this, which is the moſt uſeful propoſition of all, being the moſt certain way by which the Seaman can keep his account, is as ready performed, and juſt in the ſame manner, as in the plain chart. Neither ſhal the Seaman need to trouble himſelf, in keeping his accounts with more curious calculations: for conſidering he cannot obſerve the latitude ſo exactly but that he may miſſe therein 5 or 6 minutes: as alſo that the ſhip cannot be ſteered, ſo exactly, but that it may alter from the Rumbe ſuppoſed, many minutes, if not ſome few degrees: and ſeeing alſo, it will be eaſie to draw the lines of Rumbs and Latitudes, in a chart whoſe meridian line ſhall be about this ſize, more exactly then can be obſerved or ſteered. What profit will be gained then by more curious calculation?

Proposition 6.

The rectifying of your dead reckoning, by your obſervation. 6.

THis Propoſition is to be performed here, as is ſhewed in the plain chart, onely you muſt meaſure your diſtances by the meridian line, neer the latitude you are in.

Proposition 7.

7.

THis Propoſition is but for variety, and recollection of what was ſaid before, and to be performed in like manner upon this Chart.

Proposition 8 & 9.

8 & 9.

THeſe two Propoſitions belong onely to the plain chart or plain table, and is not ſo fit for this.

In

In all theſe Propoſitions, there are theſe four principall things to be taken notice of. 1 the Longitude, 2 the Latitude, 3 the Diſtance, 4 the Rumbe. Any two of theſe being known; the other two may be known thereby. So that theſe Pro poſitions might be varied many wayes, as you may ſee in Mr. *Gunters* Workes. But what I have ſaid already, being I hope ſufficient to inſtruct you in the nature aud uſe of the Chart, and theſe being the moſt neceſſary, I ſhal not further enlarge upon this in this place.

CHAP. V.

Of ſayling by a great Circle.

The praiſe of this way of ſayling by a great Circle

I Now come to ſhew how you may ſail bythe arch of a great Circle, which is the moſt exact way of ſayling of all others, but in regard of the difficultie that there is in the calculation thereof, it hath diſcouraged the Sea-man from looking after it: but I ſhall ſhevv you hovv this may plainly and eaſily be performed by *Geometry*, vvhich I hope vvil be for the generall profit and eaſe of Seamen. For you muſt knovv that the diſtances of places found out as vvas before ſhevved in the uſe of the Sea-chart, is ſeldome the neereſt diſtance betvveen any tvvo places, but it is onely their diſtance in the rumbe. So that if the tvvo places are not both under the Equinoctiall or both in one meridian, then there is ſomewhat a neerer cut betv veen the tvvo places, then the rumbe points out: vvhich ſometimes, eſpecially neere the Poles, is very conſiderable.

First, it is the neereſt way.

But this is not all the benefit vvhich comes by this vvay of ſayling, but many times vvhen your courſe lies neer the Eaſt and Weſt, this vvay is farre more convenient. For if you ſhould ſail full Eaſt or Weſt, you muſt altogether depend upon your dead reckoning, having no vvay to help your ſelf, by the obſervation of the latitude, but novv if you ſail by the arch of a great circle, betvveen tvvo ſuch places, you not onely go the nee-

Secondly, it is the moſt convenient way.

neerer vvay, but alſo may alter your latitude many degrees, vvhereby your account may be often rectified, * as for example, ſuppoſe you vvere to ſail from *Spain* to *Virginia*, both vvhich lye neer the parallel of 40 degrees, and ſuppoſe the difference of longitude betvveen tvvo ſuch places in the parallel of 40, to be 70 degrees, the diſtance of theſe tvvo places meaſured in the parallel of 40 (vvhich is the rumbe that leads betvveen the tvvo places being Eaſt and Weſt) is 53 degrees $\frac{62}{100}$, but their diſtance in the arch of a great circle is but 52 degrees, $\frac{08}{100}$, that is 1 degree, $\frac{54}{100}$ leſs. But this as ſaid, is but the leaſt part of the benefit that comes by this vvay of ſayling: the chiefeſt is this, that in ſayling between two ſuch places by the arch of a great circle, you wil firſt in the one half of the way raiſe the Pole 5 degrees $\frac{69}{100}$, and then in the other half depreſs the Pole as much, ſo that in your whole Voyage you wil alter the latitude 11 degrees $\frac{38}{100}$, & ſo by the obſervation of the latitude you may rectifie your dead reckoning very wel, which you cannot do, ſayling in the parallel. Thus you ſee this way of ſayling is not only the neereſt but the beſt way.

* So in the example of the *Summer Ilands* the diſtance by the rumbe is 3299 miles. The diſtance by the arch is 3204 miles, that is 95 miles leſſe.

Now concerning this way of ſayling, there hath been but little written by any, and therefore I ſhal be the more large in this. Captain *Saltonſtall* in his Booke called the *Navigator*, hath ſaid ſomwhat how to direct a parallel courſe, but for any other courſe he hath ſaid nothing, and what hee ſheweth is to be performed by Arithmetick. Maſter *Norwood* in his Book of *Trigonometry* hath added as an appendix many Problemes of Sayling by the arch of a great circle whereby thoſe; who both can, and wil take the pains, may by calculation finde out all things neceſſary in this way of Sayling. But thoſe ways of calculation as they are very difficult to the unlearned, ſo they are tedious to thoſe that have the beſt skil: and therefore I hope it will be wel accepted, if I here ſhew you how the ſame may be performed by *Geometry*, both plainly and ſpeedily, and yet with as much exactneſſe, as need be required.

Few have written of this ſubject.

The chiefe things to be known.

And in the purſuance hereof, I ſhal keep as cloſe to Maſter *Norwood*, as I can, both in his Propoſitions and Examples, that thereby you may ſee how neerly my plain lines wil approach to the exactneſſe of his calculations. Now if you obſerve him, there are theſe three things, which muſt be found out in every Example. Firſt, the diſtance of the two places in the arch of a great Circle. Secondly, the angle of poſition from the one place to the other. Thirdly, to finde out what longitudes and latitudes the arch of the great circle doth paſſe through between the two places.

To finde the diſtance of two places.

For the firſt of theſe, knowing the longitude and latitude of two places, to finde their diſtance in the arch of a great circle, which is always the neereſt diſtance. I might ſhew you how to perform this in the firſt place, but I here paſſe it by for theſe reaſons. Firſt, becauſe Maſter *Wright*, Maſter *Blundevile*, and Captain *Saltonſtall*, have all of them demonſtrated it in their Books already. And ſecondly, becauſe the chief benefit in this way of ſailing doth not ſo much conſiſt in ſaving of a litle way, as in ſayling the moſt convenient way: that is, ſo as you may alter your latitude moſt, and ſo your reckoning may be the more certain. For though neer the Poles, the difference of the diſtance of two places, in the arch of a great circle, and in their rumbe, may be conſiderable; yet in moſt Voyages it is not: as in the forenamed Example of two places in the parallel of 40 degrees, the difference by calculation is found to be but one degree $\frac{54}{100}$, which is ſcarce conſiderable in the whole Voyage, being 52 degrees. Thirdly, it wil be ſomewhat difficult, & it requires great curioſity in drawing of thoſe lines preſcribed by them ſo exactly, that you may come to the knowledge of the diſtance any thing neer. Laſtly, all that trouble is needleſſe. For though in calculation this diſtance muſt be found out firſt, that ſo you may find out the reſt of the Propoſitions following: yet in this way I am about to ſhew that which follows, no way depends upon the true knowledge of this diſtance: it ſhal be ſufficient therefore for the preſent, to tel you, that this way is always ſomewhat the neereſt way.

For the ſecond of theſe Propoſitions, which is to know the angle

angle of poſition from the one place to the other. Though this muſt be found out in calculation before you can proceed any further, yet in this work it is more needleſſe then the former propoſition, and therefore may be very well omitted.

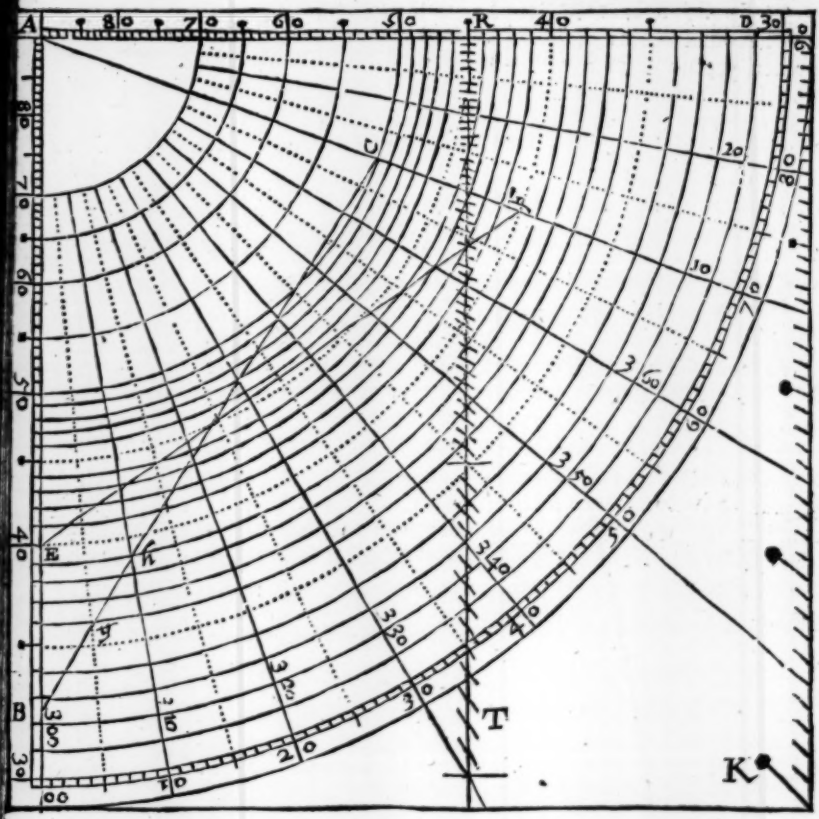
The angle of poſition is needleſs in this operation.

But now for the third Propoſition, which is the finding out by what Longitudes and Latitudes the great circle muſt paſſe between the two places, this being the very end aimed at in all the work, may be thus attained.

To finde out the longitudes and latitudes by which the great circle doth paſs.

Firſt, draw the following Quadrant A D B, and divide it into degrees; then conſider of what length your Tangent line muſt be, and accordingly ſet off your Radius from A toward D (the larger * the better, but in this Quadrant, the Radius is A R) and this Radius is always a tangent of 45 degrees. Then from the point R, draw the line R T parallel to the ſide of the Quadrant A B: this line R T is the Tangent line which you muſt divide into degrees, as you ſee in the figure by drawing ſtraight lines from the Center A to the limbe of the Quadrant. Then transferre this line to the ſides of the Quadrant A B and A D, and then ſetting one foot of your compaſſes in the center A, open the other to the ſeverall degrees in the line A B or A D and draw the arches. Now you muſt know that theſe arches are the parallels of latitude; and the ſtraight lines drawn from the Center, are Meridian lines, or the lines of longitude. The arches of latitude you muſt number as in the figure: but the lines of longitude you may number as your occaſion requires.

* You may make your tangent larger either by making your Quadrant larger, or by ſetting your Radius further from the Center, Thus in the Quadrant the line D K is a larger tangent line, which though it reach but to 45 degrees, yet by lengthening of the line, you may ſet on the reſt.



This is a projection of a part of the Globe in plano *by Naturall Tangents: You may if you pleaſe, when occaſion requires, divide a Circle into foure Quadrants, and draw the lines of Longitude from the Center, and number them to* 360, *and likewiſe deſcribe the Circles of Latitude round about the Center, and you may make this Projection as large or as little as you will by the Table of Naturall Tangents, if you lengthen or ſhorten your Radius.*

A Table of *Naturall Tangents.*

The Radius being 1000 parts.

D.	*Tã.*	D.	*Tãg.*	D.	*Tang.*	D.	*Tangẽt*
1	017	24	445	46	1,036	69	02,605
2	035	25	466	47	1,072	70	02,747
3	052	26	488	48	1,112	71	02,904
4	070	27	510	49	1,150	72	03,078
5	087	28	532	50	1,192	73	03,271
6	105	29	554	51	1,235	74	03,487
7	123	30	577	52	1,280	75	03,732
8	141	31	601	53	1,327	76	04,011
9	158	32	624	54	1,376	77	04,331
10	176	33	649	55	1,428	78	04,705
11	194	34	675	56	1,483	79	05,144
12	213	35	700	57	1,540	80	05,671
13	231	36	727	58	1,600	81	06,313
14	249	37	754	59	1,664	82	07,115
15	268	38	781	60	1,732	83	08,144
16	287	39	810	61	1,804	84	09,514
17	306	40	839	62	1,881	85	11,430
18	325	41	869	63	1,963	86	14,300
19	344	42	900	64	2,050	87	19,081
20	364	43	933	65	2,144	88	28,636
21	384	44	966	66	2,246	89	57,290
22	404	45	1000	67	2,356	90	*Infinite*
23	424		*Rad.*	68	2,475		

Let your Radius be of what length you pleaſe, firſt divide it into 10 *equall parts, and then ſubdivide each of theſe parts into* 10, *ſo you ſhall have* 100 *parts in your line, then you may, if you can, divide each of theſe* 100 *parts into* 10, *ſo you ſhall have* 1000, *But this laſt diviſion will be needleſſe, for you may by your eye gueſſe at the proportionall part. Having thus fitted your Scale of equal parts, you may prick down the line of Tangents out of this Table. Note after you are paſt* 45 *degrees in the Table, the Figure before the Comma, ſhews the whole Radius, or how many times the whole Radius is contained therein, and the three following Figures, the parts to be reckond upon the Scale as before. You will finde this Table neceſſary, either when you would make a large Tangent line to ſerve for places onely neer the Pole; Or when you would make a very little Tangent line that ſo you may bring in the degrees neer the Equinoctiall into your Quadrant.*

Ha-

The ſlank being made will ſerve for many examples, ſo that the work wil be very eaſie.

Having thus drawn this blank Quadrant, you muſt ſet down therin the two places you are to ſail between, according to their latitudes and longitudes, and then onely by your ruler draw a ſtraight line from the one place to the other, and this ſtraight line will repreſent the great circle which paſſeth between the two places, and will exactly croſſe thoſe degrees of longitude and latitude, which you muſt ſail by.

Example.

For the example and proof hereof, I ſhal take Mr. *Norwoods* example of a voyage from the *Summer Ilands* to the *Lizard*, the latitude of the *Summer-Ilands* is 32 degrees 25 minutes, let the longitude thereof be ſuppoſed to be 300 degrees, the latitude of the *Lizard* is neer 50 degrees, the difference of longitude betvveen the tvvo places is ſuppoſed to be 70 degrees, ſo that the longitude of the *Lizard* vvil be 10 degrees. And it is required to know by what longitudes and latitudes the arch of a great circle drawn between theſe two places doth paſſe.

The working of the example.

Firſt, let the line A B repreſent the meridian of the *Summer Ilands*, upon which you muſt marke out their latitude 32 degrees, 25 minutes at B, and becauſe the longitude thereof is 300: ſet down 300 at the end of the line A B, ſo the *Summer Ilands* ſhal be ſet down according to their longitude and latitude: then count ſtill forward the degrees of the difference of longitude til you come to 70 degrees in the limbe of the quadrant, and there draw the line A C 70, this line will repreſent the meridian of the *Lizard*, and upon this line you muſt marke out the latitude of the *Lizard*, which is 50 degrees at C, then lay your ruler to theſe two markes at B and C, and draw the ſtraight line B C. This line B C will repreſent the arch of the great circle between theſe two places, and if you guide your eye along in this line, you may readily and truly perceive by what longitudes and latitudes you ſhould ſail, for marke well where this line croſſeth the arches of latitude, and the lines of longitude, and that ſhews the true longitudes and latitudes of the arch of the great circle, according to your deſire.

The proof.

Now the truth hereof will more evidently appear, if you compare the latitudes and longitudes which

which this line interſecteth with this table thereof calculated by Mr. * *Norwood* for every fifth degree of longitude.

* In the tenth Probleme of ſailing by the arch of a great circle.

Longitude or difference of longitude. De. D.	*Latitude* Deg. m.	*Longitude or difference of longitude.* De. D.	*Latitude* Deg. m.
310 00	32 25	340 40	49 04
305 05	35 52	345 45	49 47
300 10	38 51	350 50	50 15
315 15	41 24	355 55	50 31
320 20	43 34	360 60	50 33
325 25	45 24	005 65	50 23
330 30	46 54	010 70	50 00
335 35	48 07		

Now you may hereby ſee, that the line B C in the point G doth croſſe the 305, or the 5 degree of longitude from B almoſt at the arch of 36 degrees of latitude, juſt as the table ſhewes it ſhould, at 35 degrees, 52 minutes of latitude. Again, the line B C doth croſſe the 310 or the 10 degree of longitude from B in the point *h*, almoſt at the arch of 39 degrees of latitude agreeing with the table which ſhews it to be in 38 degrees 51 minutes. And ſo in all the reſt it ſo neerly agrees, that if you take any care in making of this blank Map to draw the arches of latitude, and the degrees of longitude truly, you ſhal not need to uſe any calculation, though you are wel skil'd therin, for the thing hereby may be much more exactly known, then the courſe of a ſhip can be ſteered.

For the further explaining of this, take another example, which ſhal be of a parallel courſe. Suppoſe two places to be ſcituate in the parallel of 40 degrees of North latitude, and their difference of longitude to be 70 degrees, the one being in 300, the other in 10 degrees of longitude, and it is deſired to know what longitudes and latitudes the arch of a great circle being drawn between theſe two places will paſſe through.

An example of two places in one parallel.

To perform this, firſt in the line A B marke out the latitude of the one place which is 40 degrees at E. Then in that ſame arch

arch count 70 degrees of longitude, from E to F, and there make a mark for the other place, thus the two places being ſet down upon the blanke map according to their latitudes and longitudes, draw a ſtraight line from E to F, and this will repreſent the great circle, which is to be drawn between the two places, and the interſections which it maketh with the arches of latitude, and the lines of longitude will ſhew the true longitudes and latitudes by which this great circle ought to paſſe.

Proofe of the worke, by its agreement with calculation.

Now for the proof hereof though Mr. *Norwood* in his Book, hath not calculated the longitudes and latitudes of the arch of a great circle in ſuch an example as this: yet his rules ſhew how to do it, and according to them I have calculated this table, ſo that you might ſee the exactneſſe of this way by its agreement with the table.

Longitude		*Latitude*			*Longitude*		*Latitude*		
				100					100
Deg.	De.	De.	m.	parts	Deg.	De.	De.	m.	parts
300	00	40	00	00	335	35	45	41	68
305	05	41	34	57	340	40	45	35	58
310	10	42	53	88	345	45	45	15	25
315	15	43	55	92	350	50	44	42	70
320	20	44	42	70	355	55	43	55	92
325	25	45	15	25	360	60	42	53	88
330	30	45	35	28	005	65	41	34	57
335	35	45	41	68	010	70	40	00	00

or difference of longit. — *theſe minutes are in*

Note if you draw lines by every degree of longitude in the blanck Map, as there is by every degree of latitude, you may then finde out the latitude of the great circle for every degree of longitude. But this paines wil be needleſſe, yet the lines may be for ſome uſe, for if your two places differ more in latitude then they do in longitude, then it will be your better way to ſet down by what longitudes the great circle doth paſs at every fourth or fift degree of latitude.

Now that the longitudes and latitudes of a great circle thus found

found out will be exact enough for the Seamans uſe, if you be any thing carefull and handſome in drawing of the lines of latitude and longitude true, obſerve what Mr. * *Norwood* ſaith to this purpoſe, his words are theſe.

The longitudes & latitudes of the arch all us found out wil be exact enough.

Having ſpoken before the calculation hereof: but notwithſtanding all that hath hitherto been ſaid, it may ſeem hard to direct a ſhip, and to keep ſuch a rekoning as may be agreeable to this method of ſailing. And indeed as it is in a manner impoſſible, ſo neither is it neceſſary that a ſhip ſhould alwayes perſevere exactly in the arch of a great circle. It may ſuffice, and it is almoſt the ſame in effect, if a ſhip be ſo directed that ſhee go neer this arch. Which how to do he ſheweth in the next probleme, wherein I ſhall follow him, onely whereas he directs you to finde out the longitudes and latitudes of the arch of the great circle, by calculation, I have ſhewed you how to ſave that labour, and yet finde it out ſufficiently exactly for your uſe.

* See Maſter *Norwood* in his Problemes of ſaling by a great circle. *Prob.* 9. latter end.

How to uſe the longitude and laritud being found out.

Having therefore found out the longitudes and latitudes by which the great circle muſt paſſe, as is before ſhewed, you muſt likewiſe provide you a blank Sea-chart, drawing it either by the leſſer or larger Meridian line, as is before ſhewed. Then prick down in this chart the latitudes through which the arch of the great circle doth paſſe at every tenth degree of longitude Then if your chart be of the leſſer ſize, you may with your compaſſes draw an arch of a circle through thoſe pricks, and this arch will repreſent the great circle between the two places. But if your chart be of the larger ſize, and ſo your compaſſes be not large enough, to draw this circle; or elſe you are forced in regard of the length of the voyage to make two or three charts for it, then you may prick down the longitudes and latitudes of the great circle for every fift degree of longitude, and with your ruler, draw little ſtraight lines from one prick to another, and yet theſe lines wil repreſent the great circle wel enough. And thus the great circle being drawn upon the chart, you may eaſily by the former directions in the uſe of the chart, ſee what point you muſt ſteer upon

on at the beginning of your voyage, and afterward altering your courſe by halfe a point at a time, you may keep as neer to the arch of the great circle, as either you need or can expect to do.

It is not good to ſteere upon quarter points, becauſe they are not ſo viſible in the Compaſs, neither is it good to alter your courſe too often.

Now becauſe Mr. *Norwood* hath ſufficiently explained this in the example of the *Summer-Ilands*, and the *Lizard*, I ſhall paſſe by that example, onely ſetting it down upon the chart, and referre you to his directions, and ſhew you the like in a parallel courſe.

Suppoſe you were to ſail from the coaſt of *Virginia* to the coaſt of *Portugal* between two places lying in the parallel of 40 degrees north latitude, and the difference of longitude between them is 70 degrees, the firſt place being in * 300 degrees of longitude, and the ſecond place in 10 degrees of longitude, and you would ſail by the arch of a great circle, between theſe two places.

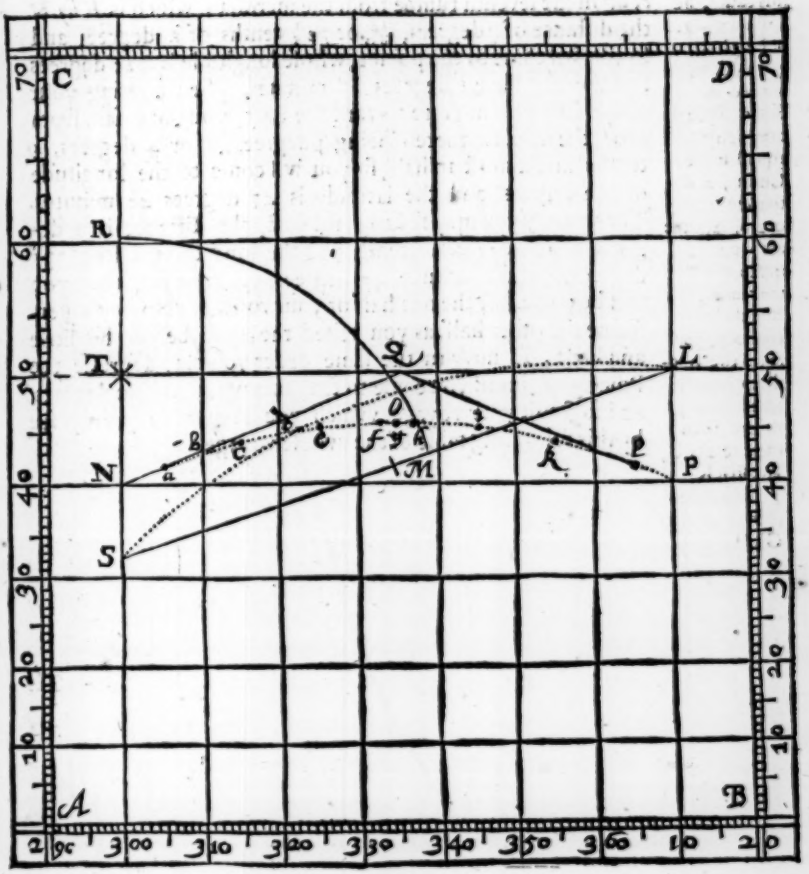
* Theſe places are not ſet down according to their true Longitudes, it is only the difference of Long. which I reſpect.

The manner of working upon the generall Chart.

Firſt, you muſt by your blank Map finde out the longitudes and latitudes by which the arch of the great circle muſt paſſe, then having drawn the following Seachart, firſt prick down the firſt place therein at N according to its longitude 300 degrees, and latitude 40 degrees. Then likewiſe prick down the ſecond place at P, according to its longitude 10 degrees, and latitude 40 degrees, then at every tenth degree of longitude from N prick down the latitude of the great circle for that proper longitude thus at *b*, which is 10 deg. of longitude from N, you muſt make a prick at 42 degrees, 53 minutes of latitude, and then at *d*, which is 20 degrees of longitude from N, you muſt make another prick in 44 degrees, 42 minutes of latitude, and ſo for every tenth degree of longitude. Then draw the circle N *a b c d e*, &c. to P, and this will repreſent the arch of the great circle between theſe two places. And hereby you may ſee how you muſt ſhape your courſe, *viz.* as * followeth. Firſt, you muſt ſail from N to *a*, upon the ſixt rumbe from the Meridian which is *E N E*, 4 degrees, $\frac{09}{100}$, or 41 tenths of a degree, ſo you will be in the point *a*, whoſe longitude is 305 degrees, and the latitude thereof is 41 degrees, 34 minutes. Then you muſt ſail from *a* to *c*, half a point more Eaſterly, 7 de-

The courſe you muſt ſteere upon.

* It may ſeem to ſome that this Circle N O P cannot be the neereſt way, but


C
D
R
T
Q
L
O
N
M
P
S
A
B
70
60
50
40
30
20
10
290
300
310
320
330
340
350
360
10
20

7 degrees $\frac{60}{100}$ or 77 tenths, or double leagues, ſo you will be in the point *c*, whoſe longitude is 315 degrees, and the latitude thereof is 43 degrees, 48 minutes. Then you may ſail from *c* to *e*, upon the ſeventh rumbe from the meridian, which is *E by N* the diſtance of 7 degrees, $\frac{26}{100}$, or 72 $\frac{1}{3}$ tenths of a degree, and ſo you wil come to the point *e*, whoſe longitude is 325 degrees and the latitude 45 degrees 13 minutes. Then altering your courſe half a point more toward the Eaſt, you may ſail from *e* to *f*, the diſtance thereof being 4 degrees $\frac{93}{100}$, or 4 degrees, 9 tenths, and almoſt an half, ſo you wil come to the longitude of 332 degrees, and the latitude is 45 degrees 42 minutes. Then from *f* you may ſail to *g*, ful Eaſt, the diſtance is 2 degrees $\frac{09}{100}$ or 2 degrees, 1 tenth, and the longitude wil be 335 degrees, and the latitude 45 degrees, 42 minutes, thus you vvil be come juſt the one half of your voyage. Novv to performe the other half, as you raiſed the Pole before by little and little, ſo novv in the ſame order you may depreſſe the Pole again, untill you come to the ſame parallel of 40 degrees, and ſo finiſh your voyage, vvhich you may more plainly ſee by this followving table of the vvhole voyage.

but rather the ſtraight line of N P, but this proceeds from this cauſe, becauſe the deg. of longitude grow ſtill leſſer toward the Poles, though they be made equall in the Chart, and therefore the deg. of latitude are made larger to anſwer thereunto. But on the contrary, you ſee in the quadrant that the line E F, is ſhorter then the circle E F, and ſoit is plainly to be ſeen upon the Globe.

The

The ſeverall places where you alter your courſe.	*The courſe you ſteere.*	*The diſt. or way ſailed*		*The Longitude*		*The Latitude*		
		Deg.	P.	Deg.	m.	Deg.	m.	P.
1 from *N* to *a*	*E N E*	4	09	305	0	41	34	57
2 from *a* to *c*	½	7	69	315	0	43	48	80
3 from *c* to *e*	*E b N*	7	26	325	0	45	13	22
4 from *e* to *f*	½	4	93	332	0	45	42	70
5 from *f* to *g*	*Eaſt*	2	09	335	0	45	42	70
6 from *g* to *h*	*Eaſt*	2	09	338	0	45	42	70
7 from *h* to *i*	½	4	93	345	0	45	13	22
8 from *i* to *k*,	*E by S*	7	26	355	0	43	48	80
9 from *k* to *l*	½	7	69	005	0	41	34	57
10 from *l* to *P*	*E S E*	4	09	010	0	40	0	0
The Summe		52	12					

You muſt not thinke to finde theſe courſes and diſtances which I have ſet down in this table, can be ſo exactly found out by the former generall chart, which is drawn by che leſſer Meridiau line, but if you draw two or three blank charts by the larger meridian line, in two or three ſheets of paper, you may then finde them out eaſily, and as exactly as need be. In theſe ſeveral charts, you may ſet down your dayly courſes and diſtances, and then when you pleaſe you may prick down the ſumme of theſe reckonings upon the generall chart, and thereby the better ſee whereabouts you are in reſpect of your whole voyage. Thus you may eaſily, know the ſeverall parts, and the total ſumme of your voyage at any time.

How to work upon a larger Chart.

Or elſe you may keep account of ſuch a voyage as this, and finde out all your diſtances and courſes upon one blank chart, drawn in a ſheet of paper, (or leſs if you pleaſe) as in the figure following. But I would not wiſh you to ſcant your ſelf to ſo ſmall a chart as this is, this being ſo little, onely in re-

A way to avoid drawing of many Charts.

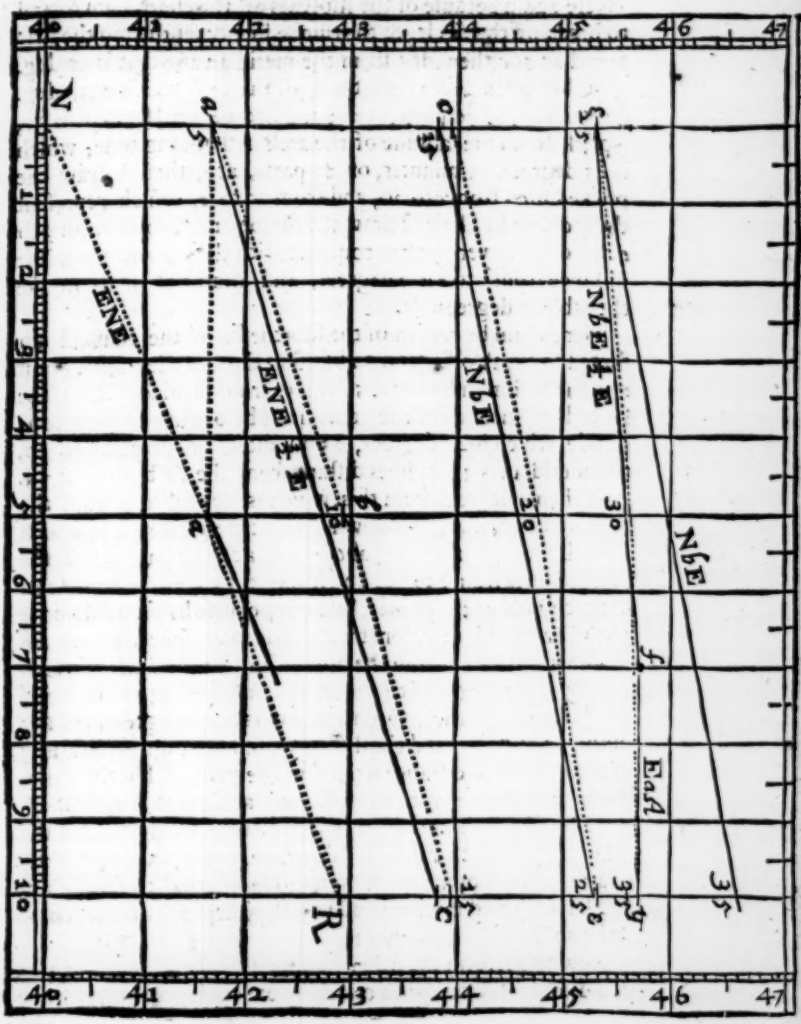
regard of the littleneſſe of the book, and ſo the lines are broken off, oftner then otherwiſe you need to do.

Now in this following chart, being fitted to the latitudes you muſt ſail under, firſt ſet down your firſt place N according to the latitude thereof, which is 40 degrees, then prick down the latitude of the great circle, at the firſt fift degree of longitude, which is 41 degrees, 34 minutes at *a*, then laying your ruler from N to *a*, pricke out the line N *a*, which will repreſent the arch of the circle from N to *a*. Then the latitude of the circle for the next 5 degrees, is 42 degrees, 53 minutes, or $\frac{88}{100}$ parts, this muſt be ſet down at R, and then draw the pricked line from *a* to R, ſo you have the arch of the circle from N to R. Now if you would know what courſe you muſt ſteer: by your ſcale of rumbes you ſhal finde that from *N* to *a*, the courſe is *E N E*, and the diſtance from N to *a* meaſured in the meridian line, is 4 degrees, $\frac{1}{10}$, or 41 tenths of degrees. And here now becauſe the rumb line doth run above the arch of the circle at *a*, I leave this courſe and alter my courſe halfe a point more towards the eaſt.

Alſo in regard of the ſhortneſſe of the chart, I am forced to break off the arch of the great circle at *a*, and ſet down the latitude thereof in the firſt meridian again at *a*, and ſet down the latitude thereof in the firſt meridian again at *a*, drawing a line from *a* to *a*, then 5 degrees from this meridian that is 10 degrees, from the firſt place N, I ſet down the latitude of the great circle, which is 42 degrees, 53 minutes or 88 parts at *b*, and 5 degr. from *b*, that is 15 degrees from N, I ſet down the latitude of the circle, which is 43 degrees, 55 minutes, or 92 at *c*, and prick out the lines *a b* and *b c*, which repreſent the great circle, then by a ſcale of rumbes, I ſet off 6 rumbes and a half, which is the black line *a c*, which almoſt meets with the pricked circle at *c*, and the diſtance from *a* to *c*, is 7 degrees $\frac{7}{10}$, as you may finde by meaſuring it in the meridian line. And note though the rumbe line and the arch of the circle, do not here cloſe exactly, yet it is no matter: for I have drawn it thus to even 5 and 10 degrees that it might agree with what hath been before ſaid.

Take theſe Latitudes out of the Table, *page* 56.

Here


N
ENE
ENE ½ E
NbE
NbE ½ E
NbE
EaA
R

Here again becauſe of the ſhortnes of the chart I am forced to break off the circle, & the rumbe line, & ſet them in the firſt meridian at *c*, then 5 deg. from the meridian at *c* that is 20 deg. from N, I prick down the latitude of the arch, which is 44 deg. 42 minutes, or 70 parts, at 20; and five degrees from this 20, I prick down the latitude of the arch in that longitude, which is 45 degrees, 15 minutes, or 25 parts, at *e*, then I draw the pricked lines from *c* to 20, and from 20 to *e*, which repreſent the arch, and I likewiſe draw the rumbe line *N by E* from *c* to *e*, which doth very neerly concurre with the arch at *e*, and the diſtance from *c* to *e* is 7 degrees, and almoſt $\frac{1}{10}$ or 15 in the the table, 7 degrees, $\frac{16}{100}$.

Here again by reaſon of the ſhortneſſe of the chart, I am forced to break off again, and ſetting the latitude of this point *e*, in the firſt meridian at *e*, 5 degrees from this I ſet down the latitude of the arch of the great circle belonging to that longitude, which is 45 degrees, 35 minutes, or 58 parts at 30, this meridian is 30 degrees diſtant from the firſt place at N. And then 5 degrees from this, which is 35 degrees from the firſt meridian at N, I ſet down the latitude of the arch, which is 45 degrees, 41 minutes, or 68 parts at *g*, then I draw the pricked lines from *e* to 30, and from 30 to *g*; this repreſents the arch, now at the point *e*, I alter my courſe half a point more to the Eaſtward, therefore by the ſcale of rumbes, ſetting off 7 points and a half from the point *e*, I draw the line *e f*, which is *N by E*, half a point to the Eaſt: and having ſayled upon this point from *e* to *f*, the latitude will be 45 degrees, 42 minutes, or 70 parts, and the difference of longitude from *e* is 7 degrees, and the diſtance from E is 4 degrees, $\frac{2}{100}$, but the difference of longitude from the firſt place at N, is 32 degrees.

Laſtly, becauſe now I am as farre to the Northward as the arch of the great circle will allow me, I here at *f* alter my courſe halfe a point more, and ſo ſail from *f* to *g* full Eaſt, ſo I have altered my longitude in all 35 degrees, and am come juſt one halfe of the voyage.

Now to perform the other half, you muſt continue to do as you did before, firſt prick out the great circle, and then finde

out

out the rumbes you muſt ſail upon from one point to another, which you may alter now and then half a point, and ſo you may lay the Pole in the ſame order and proportion that before you raiſed it, as you may ſee by the table before, *page* 61.

CHAP. VI.

Shewing ſome obſervations which may be of uſe in all theſe three kinds of ſayling.

HAving ſhewed you how to ſail, either by the Rumbe that leads from one place to another, or elſe by an arch of a great circle extended between two places, I ſhal now lay down ſome obſervations, which may be uſefull in either of theſe wayes of ſayling; for ſometimes it is beſt to uſe the one way, ſometimes the other, in ſome voyages it is beſt to ſail by the Rumbe, in ſome voyages it is beſt to ſail by the arch, in ſome voyages it is the beſt way to uſe both, and to keep neither to the rumbe nor to the arch exactly.

In voyages to the *Weſt-Indies*, though the neereſt way, be by the arch of a great circle; and though the way by the direct Rumbe, lies very wel: yet it is uſual in theſe voyages to ſteer wide from both theſe neerer ways, *viz.* firſt, to ſteer much more to the Southward then the courſe lies, until they come into the latitude of the place, and then to run their courſe Weſt, until they arrive at their deſired port. And this way is very good, eſpecially when you ſail unto a little lone Iſland. For firſt, by ſayling toward the Line, you ſhal gain the benefit of the *Tradewind* (as they call it) which doth moſt conſtantly blow between the North and Eaſt, between and neer the *Tropicks*. Secondly, hereby you may be ſure not to overſhoot the Iſland you would ſayl to, which otherwayes may eaſily be done. For it is an hard matter in a long voyage, to ſteer your courſes ſo exactly, and keep your account of your way ſo perfectly, as not to miſſe ſome few leagues: and beſide

To get the benefit of the winde.

To avoyd overſhooting the place you go to

ſide if this could be done, yet the courſes and diſtances can not be ſo exactly known, becauſe the true longitudes of places one in reſpect of another is not ſo exactly found out, as is to be wiſhed for. And if by either of theſe cauſes, when you ſhall come to the end of your reckoning, you ſhal chance not to be in ſight of the Iſland, you wil then be at ſuch a loſſe, that you wil not know which way to ſail to finde it, whether Eaſtward or Weſtward, and ſo muſt be forced to vvander at randome untill you have a ſight of ſome knovvn place, by which you may knovv hovv the Iſland bears from you. Therefore in ſayling to ſuch a place as this; it is the beſt vvay to be ſure to get into the latitude of the place, a good while before you come to it, and then ſayling neer that latitude, you ſhall be ſure not to paſſe by it without a ſight of it.

2 To get a wind.

In voyages from the *Weſt-Indies*, the uſual way is firſt to ſail much more northerly, then the true Rumbe doth lie, and this likewiſe is to get the benefit of the wind, for as the winde lies moſt Eaſterly toward the Equinoctial, ſo it blows moſt weſterly towards the Pole: alſo this way is the neereſt way, becauſe it lies neer the arch of a great circle. But many Seamen not knowing ſo much, and eſpecially keeping their reckoning upon the plain chart, this convenience might prove an inconvenience to them for they are many times at their journeys end 150 or 200 leagues before they are aware, and ſo might eaſily overſhoot their port, and loſe themſelves, but that they ſail to the maine land, or great Iſlands that they cannot paſſe by.

3 The inconvenience of ſailing in a parallel.

Now as for theſe cauſes you ſometimes ſtray from the rumb or arch which lies between the two places, ſo there is another conſideration which may be a ſufficient reaſon for a little wandring, ſometimes out of the way, and that is the inconvenience that there is, in ſayling far upon a courſe of Eaſt or Weſt. Becauſe you muſt always depend upon your dead reckoning which is ſubject to much miſtake, having no way to correct it by obſervation. This parallel ſayling makes the journey many times ſeem tedious. As a man that travails in an unknown way, thinks the miles and the way to be longer then indeed they are,

whereas

whereas he that knows the road and how farre it is from place to place, goes on more chearfully. Therefore the labour wil not be loſt if you go ſometimes a little out of your way for this conſideration, that ſo you may have the more certainty of your account.

How to avoid ſailing in a parallel, partly.

Indeed the way of ſailing by the arch of a great circle doth very much help in this, as I have ſhewed at large in the former Chapter, but yet if you keep your ſelf in your voyage too ſtrictly to the arch, you muſt runne much of your way in a parallel, or very neer it. As in the example of the parallel voyage in the laſt chapter, the difference of longitude between the two places being 70 degrees, if you keep to the arch, you muſt firſt ſail *E N E*, til you alter your longitude 5 degrees, then halfe a point more Eaſterly, til you alter your longitude 10 degrees more, then you muſt ſail *N by E* til you alter your longitude 10 degrees more, that is in all 25 degrees, but afterward the 7d egrees which are ſet down half a point off the Eaſt, and the three degrees ful Eaſt, is little better then a parallel courſe: then again this being the middle point of your voyage, you muſt ſail 10 degrees more in the ſame proportional courſe, ſo that of the 70 degrees of the whole voyage you muſt ſail 20 of them neer the courſe of Eaſt and Weſt.

How to avoid ſailing in a parallel, totally. * Page 63.

Now you ſhal ſee how eaſily this may be avoyded, and that ſeveral wayes: firſt let the courſes be continued as before til you come to 25 degrees difference of longitude, which is at *e* in the laſt * chart, then if at this point you leave the great circle a little, and keep on your courſe ſtil upon the 7 rumbe *N by E*, til you come to 35 degrees of longitude, your latitude wil be 46 degrees, 36 minutes, or 60 parts, differing from the latitude of the arch 55 minutes, but your diſtance for theſe 10 degrees of longitude wil be but 7 degrees $\frac{00}{100}$, that is but $\frac{7}{100}$, more then the other way, which makes but 4 miles, which makes 4 miles, which is ſo little that it is not to be regarded in reſpect of the diſtance in theſe 10 degrees, being 425 miles.

Again if you begin ſooner to ſwerve from the arch, yet the difference of your way wil not be much, as you may ſee by this table which differs much from the other in the rumbes,

latitudes, and longitudes, but yet it differs but little in the total ſumme of the diſtances, being but $\frac{20}{100}$, which is but 12 miles.

Difference of Longitude.		*The courſe or Rumbe.*	*Diſtance or way ſayled.*		*The true Longitude.*		*The Latitude.*	
Deg.	m.		Deg.	P.	Deg.	Min.	Deg.	Min.
10	0	*E N E*	08	10	310	043	6	
10	0	$\frac{1}{2}$	07	46	320	045	16	
15	0	*E by N*	10	60	335	047	20	
15	0	*E by S*	10	60	350	045	16	
10	0	$\frac{1}{2}$	07	46	360	043	6	
10	0	*E S E*	08	10	010	040	0	
The Summe			52	32				

See the generall Charr, page 58.

Once * again if you try another way, as if you ſhould ſail from the firſt place N, in the latitude of 40 degrees, upon the 6 rumbe *E N E*, til you have altered your longitude 35 degrees, which is the half of your voyage, you wil then finde your ſelfe to be at Q, in the latitude of 50 degrees, 12 minutes, and your diſtance or way ſayled, will be 26 degrees $\frac{63}{102}$. Then if from this point you alter your courſe, and ſail upon the 6 rumbe Southward, again, *E S E* to *P*, your diſtance wil be as before 26 degrees $\frac{63}{100}$, and ſo you wil come to the latitude of 40 again, being the place you deſire, ſo that your whole voyage by this reckoning wil be but 52 degrees $\frac{26}{100}$, w^h though it be ſomewhat more then the diſtance by the arch, which is 52 degrees, $\frac{03}{100}$, yet it is leſſe then the diſtance of theſe two places, in the parallel which is 53 degrees, $\frac{62}{100}$, and the loſſe of the way wil be wel recompenſed, eſpecially in ſailing from the *Indies*, by the advantage of the wind, and by the certainty you may keep off your account, ſayling alwayes upon the ſixt rumbe.

By

By this alſo it appears, that the longitudes and latitudes of the arch of a great circle, and the courſes and diſtances which you are to ſail upon, in tracing thereof, may be ſufficiently found out in the tracing thereof, may be ſufficiently found out by the wayes before ſhewed, ſo that there needs no other calculation for them, ſince a ſmal wandring from them, will not alter the length of the way in any conſiderable quantity.

To avoyd ſailing Eaſt or Weſt at any time.

Thus alſo you may eaſily avoid ſayling upon a courſe of Eaſt & Weſt. Which way ſoever your voiage lies, it wil be your beſt way to ſteer no neerer to the Eaſt or Weſt, then the 7th rumbe from the meridian. For ſo you may by your obſervation of the latitude, correct your account which otherwiſe you cannot do, and in doing thus, you vvil not go much out of your vvay. For ſuppoſe you vvere to ſail betvveen tvvo places, under the Equinoctial line, ſo that the direct and neereſt way between theſe two places, lies ful Eaſt and Weſt, yet you may ſayl between theſe two places upon the ſeventh Rumbe, and go not much out of your way. For example, let the two places be diſtant 10 degrees, if you firſt ſail the one half of your way upon the 7 Rumbe, that is till you have altered your longitude 5 degrees, you wil raiſe the Pole very neer one degrce, *viz.* $\frac{994}{1000}$, and your diſtance or way ſayled will be but 5 degrees, $\frac{1}{10}$ almoſt, *viz.* 5 degrees, $\frac{698}{1000}$. Then if you alter your courſe, and ſo lay the pole as much upon the 7 Rumbe the other way; ſo you wil come to the place deſired, having run the ſame diſtance as before: thus in a voyage of 10 degrees, or 100 tenths or double leagues, you go not fully 2 tenths out of your way, which is not one in 50, which wil be wel recompenſed, becauſe in ſailing thus upon the 7 Rumbe, you may by the obſervation of the latitude correct your account. For this rumbe raiſeth or depreſſe the Pole almoſt one degree in ſayling of five, which wil ſerve very wel to correct your account by, and therefore I wil not perſwade you to go any further, out of your way. And if you direct your courſe according to this rule, this is the fartheſt that you need go out of the way. For in all other places, the arch of the great circle, wch is the neereſt way between two places, doth always lie ſomewhat between the Pole, and the parallel.

parallel of Eaſt and Weſt, and therefore in raiſing the Pole upon the 7 Rumbe, you wil not go altogether ſo much out of your way, if you obſerve to incline your courſe alwayes toward the Pole. Thus you ſee you need not ſayl directly Eaſt or Weſt at any time unleſſe it be when you feare you ſhal paſs by ſome little lone Iſland, as is aforeſaid.

4 Make uſe of the Sea chart and the Map, or Globe *in plano, pag.* 52. both together.

In voyages neer the Pole it is beſt to guide your ſelf as neer the arch of the great circle as you can, having reſpect to the former conſiderations. And in theſe voyages your beſt way wil be to keep your reckonings, both upon the Chart and upoe the Map, ſo the one wil help the defects of the other. As for example, the Rumbes from one place to another, are eaſieſt to be found out upon the chart, but the diſtances of the places, and the arch between them wil be found out more eaſily by the Map. For the places being ſet upon it according to their longitudes and latitudes, wil be more compoſed and hold better conformity to the Globe, being in a manner the ſame with it, eſpecially within 10 or 20 degrees from the Pole. Thus then if you are to ſail upon diſcovery, and not to a certain place, your beſt way wil be; by the rumbe which you ſail upon, and by the latitude which you finde by obſervation, to finde out the longitude of the place you are in at any time by the chart, and then ſetting down this place, according to its longitude and latitude thus found out, upon the Map, you may more readily ſee its diſtance and poſition from any other place. But if you are to ſail to a certain place, whoſe longitude and latitude is known, then it wil be beſt, to ſet the place down firſt in the Map, and ſo to finde out the longitudes and latitudes of the great circle between them, which being pricked down upon the chart, you may ſee how to ſteer your courſes to the place appointed.

5 To find out if there be any current.

In all your voyages it wil be a good way to keep your accounts upon two blanck charts, upon the one, you may keep your dead reckoning, upon the other, your corrected account. And the benefit hereof wil be this: if you be careful to keep your dead reckoning outward, and homewards true, you may thereby whether there be any current between the two places, and

and which way that current ſets, and how faſt it runnes. For if there be a current between the places you ſail to, which way ſoever the current ſets, your reckonings outward and homeward wil not agree, and indeed you can keepe no good account of your way, til you know which way and how faſt the current runnes.

For example: firſt, ſuppoſe the current runnes Eaſt 12 miles a day, and you ſayl againſt this current accordiug to your account, by your Log-line (which is the beſt meaſure of your dead reckoning) 60 miles Weſt in a day, your true pace or diſtance wil be but 48 miles in a day, becauſe the current wil ſet you back 12 miles, which ſubſtracted from 60, there remains but 48. On the contrary, if you ſayl Eaſtward in this current, (and ſo ſayl with it) 60 miles a day according to your log-line, then your true motion wil be 72 miles a day, becauſe the current wil ſet you forward 12 miles more then you ſeem to goe.

Secondly, ſuppoſe the current run Eaſt one mile an hour, if you ſayl in this current *N E* or *S E*, look how many hours you ſail, ſo many miles the ſtream wil ſet you more forward in your longitude, then yon are avvare of; aud yet your latitude, vvil fal out according to your account. On the other ſide if you ſayl *N W* or *S W* in this current, the current vvil drive you backvvard ſo many miles, and yet your latitude vvil be according to your account.

Thirdly, if the current run upon any rumbe betvveen the meridian, and the Eaſt or Weſt, then your true motion vvil differ from your dead reckoning, and alſo from your account by obſervation, both in longitude and latitude, ſo that until you knovv in ſome ſort both vvhich vvay and hovv faſt the current runs, you can never keep a good account of your vvay and the onely way to finde out the current is to keep a good account by the log-line outvvard and homevvard, and by ſetting this dovvn upon your blanck chart you may plainly ſee vvhich vvay the current runs, and hovv faſt, as *Maſter Norwood* hath very vvel demonſtrated in the end of his *Sea-mans Practice*.

In

6 To alter your courſe as ſeldame as you can.

In moſt voyages, it wil be good to keep your courſe conſtantly, (or as much as you can) upon one and the ſame rumb, for ſo your account wil be more eaſily and certainly kept. For at every ſhifting of your courſe, the true point that you are in, cannot be ſo certainly known, but that you may miſreckon ſomewhat both in the latitude and longitude thereof. For the latitude by which you have the moſt certainty of your place, may be miſtaken 5 or 10 minutes, by any inſtruments ordinarily uſed, and this may cauſe 20 or 30 minutes errour in the longitude, and this errour, at every changing of your courſe, may as wel chance to be increaſed, as to be ballanced one time with another, whereas if you ſteer your courſe conſtantly upon one rumbe, as it wil avoyd the trouble of drawing ſo many rumbe lines, ſo there can be no greater errour in your account, then there ſhal happen to be in the laſt obſervation of the latitude, which cannot be much. But if you are forced to ſhift your courſe in regard of the wind, then in the correcting of your account, obſerve the rule in the ſecond caſe of the ſixt Propoſition of the plain chart, drawing a ſtraight line from your firſt place to the place you are then in.

7 To gain ſight of land when you can.

It vvil not be amiſſe as often as you can, to get a ſight of ſuch Capes, Headlands or Iſlands, as lye neer your courſe, which being ſtanding marks, wil give you certain knowledg, vvhereabouts you are, and ſo you may the better direct your courſe and perfect your account.

8 To obſerve the variation of your Compaſs.

Laſtly, you muſt have an eſpecial care of your compaſſe, that it be every way perfectly and exactly made, and likewiſe you muſt be as careful, that you ſteer your courſe exactly upon that rumbe you reckon on; to vvhich end, not onely the Steerſ-man muſt be diligent to keep the ſhip to the courſe appointed, but you muſt be frequent in obſerving the variation of the compaſſe, vvhich may be ſo vvel performed by the Sea rings in uſe among Sea-men, that no Inſtrument can be deviſed fitter for the purpoſe, this variation being knovvn, muſt be allovved for in your account, that ſo you may knovv the true rumbe you ſail upon, vvithout vvhich there can be no true account kept.

CHAP.

CHAP VII.

Of ſayling by a great Circle.

ALthough the way already propoſed for the finding out of the arch of a great circle, between two places, is the moſt eaſie and plaineſt way that can be, yet becauſe it is not ſo general as to take in all places, but is onely to be uſed when the two places are both, on the one ſide of the Equinoctiall: as alſo it may ſeem ſomewhat defective, becauſe it doth not ſhew the diſtances of places; I have therefore here added this ſecond way, partly for variety, and partly to ſupply the defects of the former. But as this way is more artificial, ſo it is more difficult, both in the demonſtration, and practiſe, which cannot be avoided. But you may the better bear with it, becauſe you wil ſeldome be forced to uſe this way, but may very wel content your ſelf with the other in moſt voyages.

Another way to find out the longitudes and latitudes of the arch of a great circle.

This and all other queſtions of this nature, concerning the reſolution of any ſpherical triangle, may very eaſily be performed by the Globe: but becauſe the Globe is a chargeable Inſtrument, and ſo every one cannot have it: therefore ſeverall men have for ſeverall uſes invented ſeverall wayes to project the Globe upon a Plane. You may ſee the ſeverall projections thereof in Mr. *Gunters* book of the Sector. The fitteſt for this purpoſe wil be that of *Gemma Friſius*, which is moſt uſed in Maps of the whole world, the projection whereof is, as followeth.

How to deſcribe the Globe *in plano*.

Firſt, draw the circle A D B C, and divide it into four parts or quadrants, by the croſſe diameters, A B and C D, then divide each quadrant, into 90 degrees and number them as in the figure, then if you keep one end of your ruler fixed at the point A, and lay the other end to the ſeveral degrees in the lower Semicircle, D B C, ſo you ſhal divide the Diameter C D into its parts, which are half tangents. In the ſame man-

ner, if you keep one end of your ruler fixed in the point C, and lay the other end to the ſeverall degrees of the Semicircle A D B, you may divide the diameter A B into halfe tangents.

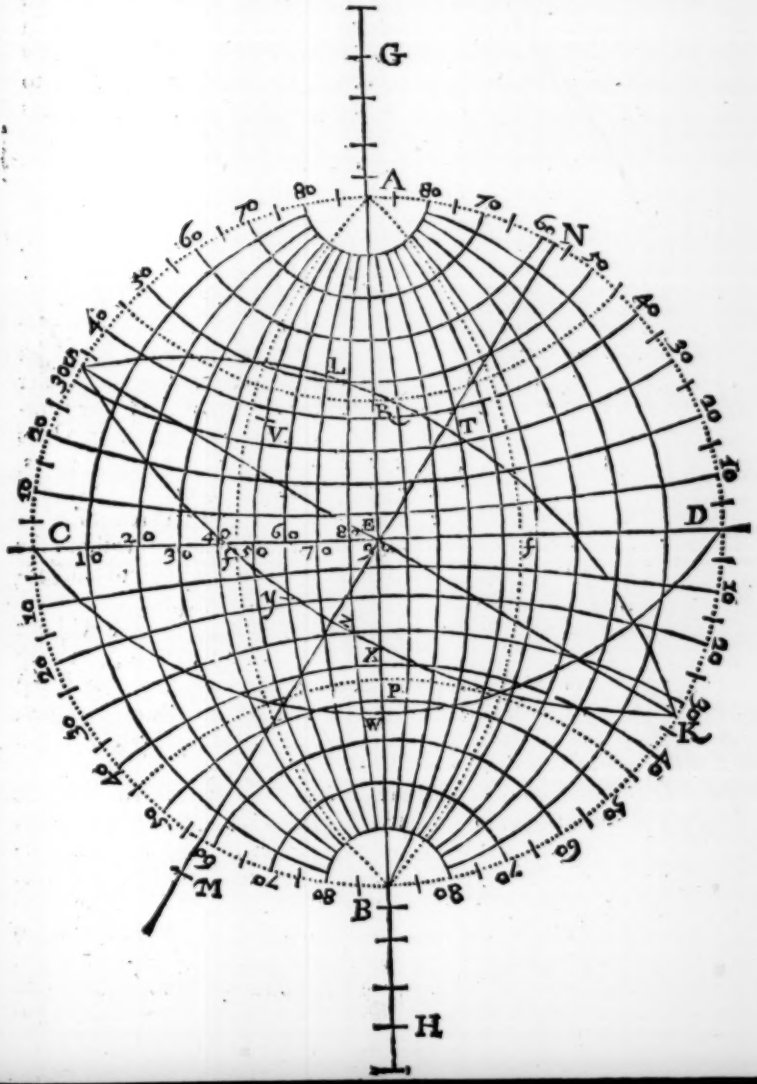
How to draw the Meridians and Parallels.

Having thus divided the circumference and the diameters, they muſt guide you in the drawing of the meridians and the parallels, which are all parts of perfect circles, and you may finde their centers by theſe three points. Firſt, for the Meridians, they all concurre in both the Poles A and B, and their third point is their correſpondent degree in the diameter C D. Then for the parallels, two of their points are their degrees in the outward circle, and their third point is their correſpondent degree in the diameter A B. By theſe three points you may finde the center, and ſo draw the arch as is ſhewed in the firſt chapter. But to ſave that labour, you muſt know, that the centers all lie in the diameter lines, which muſt be extended beyond the circle, and then the centers are thus found out. The diameter C D being divided into half tangents as before, if for every degree you account two, beginning from the center E, ſo you ſhal have the centers of the meridians. Then if you ſet one foot of your compaſſes in that center, and open the other to the Pole A or B, it wil paſſe through the correſpondent degree, or third point in the diameter C D: on the other ſide of the center, ſo the meridian wil be drawn upon the one ſide. Then with the ſame diſtance of your compaſſes, you muſt draw the other anſwerable to that on the other ſide. Then keeping your compaſſes yet at the ſame diſtance, ſet one foot in the center E, and with the other, marke the diameter A B, both above and below, and theſe markes ſhal be the centers of the parallels. Then ſet one foot of your compaſſes in theſe centers, and cloſe your compaſſes, til the other foot reach to that degree of latitude in the outward circle and ſo draw that arch from ſide to ſide. And if you finde that the arches thus drawn, do paſſe exactly through their three reſpective points, in the circle and diameter, your work is true, otherwiſe not.

Example in the Meridians and Parallels of 45 degrees.

For example, if you would draw the meridians and parallels of 45 degrees, firſt the tangent of 45 being doubled, makes

90,


G
A
N
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M
B
H

90, which counted both ways from the center E doth reach to C and D, therefore ſetting one foot of your compaſſes in C or D, and opening the other to the Poles at A or B, draw the two like arches A ſ B, on either ſide the center. Then to draw the parallels of 45 degrees, keep your compaſſes at this diſtance, and ſetting one foot in the center E, with the other croſſe the diameter A B, both above and below in the points G & H, theſe are the centers for the parallels of 45, therefore ſet one foot in the center G, and cloſe the other, till it reach to 45 degrees in the outmoſt circle, and ſo draw the arch 45 R 45. Then ſet one foot of your compaſſes in the other H, & ſo draw the other parallel 45 P 45. thus theſe 4 arches are drawn.

And thus you may eaſily doe for any other degree under 45, but when you come to the degrees above 45, then you muſt extend the line C D, and laying one end of your ruler to the point A, and theother to the degrees of the upper ſemicircle, you may divide that part of the line without the circle as you did before that part which was within, into half tangents, and ſo doubling your degree find out the center therof. Or elſe when you draw the former meridians, you may remember to turne about the compaſſes, and marke the line C D without the circle; by theſe markes you ſhal divide the line into half tangents, and ſo you may finde out the centers as before.

How to help your ſelf when your compaſſes wil not reach.

But becauſe ſome of theſe centers, wil fal ſo farre without the circle, that your compaſſes will not reach them; you may then bridle a thin ruler, that wil bend, with a double ſtring like a croſſe bow, and then by tvviſting the ſtring together, you may by little and little, ſet it to what bent you pleaſe, till it ſhal cut the three points of your arch you would draw, and then vvith your pen, you may dravv your arch, vvhich if the ruler be all of one thickneſſe, and ſo bend in all places alike, it vvil be very true. Your compaſſes vvil reach the centers very vvel, til you come to 60 degrees, but aftervvard you muſt be forced to uſe this or ſome ſuch like way to help your ſelf. The larger you make your draught, and the more meridians and parallels you draw in it, ſo much the better it is, therefore if you can, make it ſo large that you may draw meridians and

pa-

parallels through every degree, which you may do very wel in a ſheet of large paper in a leſſer draught, you may draw every ſecond degree, which is the leaſt I would wiſh you to do.

Laſtly, to ſave time and labour in drawing of theſe blanks for every queſtion: when you have made a little triall and know how to draw them, then draw two good large ones of one and the ſame ſize, which you may do very well by drawing the ſame lines in both, before you ſtir your compaſſes from their diſtances: then fix the one of theſe to the other by their centers ſo that they may be turned round, and the uppermoſt of theſe being drawn in fine thin paper, and a little oyled, you may eaſily ſee through it all the lines of the other. And thus you ſhal have an * Inſtrument whereby this and moſt other queſtions of ſpherical triangles may be reſolved.

* This wil be ſomewhat like Mr. *Blagraves* Mathematicall Jewell.

Having thus ſhewed the drawing of this projection, I ſhal now come to ſhew you the uſe of it in ſeverall examples. The firſt example ſhall be the fore-mentioned voyage from the *Summer-Iſlands*, to the *Lizard*, the latitude of the *Summer-Iſlands* being 32 degrees, 25 minutes North, and the latitude of the *Lizard*, being 50 degrees North, and their difference of longitude being 70 degrees, and it is required to know firſt the latitudes and Longitudes by which the arch of a great circle drawn between theſe two places doth paſſe. Secondly, the angle of poſition from the firſt place to the ſecond. Thirdly, the neereſt diſtance between the two places.

The uſe of this projection in finding out the great circle.

To perform this, firſt you muſt ſet down upon your draught, the firſt place which is the *Summer-Iſlands*, according to the latitude thereof which is 32 degrees, 25 minutes in the outmoſt circle at S. * And herein you muſt regard how the ſecond place doth beare from the firſt. If the ſecond place lie Weſt from the firſt, then you muſt ſet down the firſt place on the Eaſt or right ſide of the circle: but if the ſecond place lie Eaſtward from the firſt, as it doth in this example, then you muſt ſet down the firſt place on the Weſt-ſide of the circle, as it is here at S. Then from the point S through the center E, draw the diameter line S E K, and croſſe it at right angles with the line M E N. Then accounting 70 degrees (which is the dif-

Firſt example.

* Note well which way the firſt place beares from the ſecond.

difference of longitude of the two places) in the diameter C E from C to 70, mark that meridian arch, & thereupon mark out the latitude of the other place which is 50 degrees at L. Thus the two places are ſet down according to their latitudes and the difference of their longitudes at S and L. Now to help you to draw the arch of a great circle between theſe two places S & L, you have theſe three points S L & K, by which you may finde the center of the arch which is at M, in the line N M, therefore ſet one foot of your compaſſes in M, and opening the other to any of the three points, draw the arch S L K. This arch is the great circle that paſſeth through theſe two places, by which you ſhal finde all the things deſired.

The longitudes and latitudes of the arch.

As firſt, if you would know by what longitudes and latitudes this arch doth paſſe (which is the thing moſt needful to be known) if you trace the way of this arch, through the meridians and parallels of the draught, you wil finde them to agree with the former table hereof for every fifth or tenth degree. For at 10 degrees of longitude from S, the arch paſſeth through 39 degrees of latitude: at 20, through 43 ½, and ſo of the reſt.

The angle of poſition.

Secondly, if you would know the angle of poſition from S to L, then obſerve in what point the arch S L K doth croſſe the line N M, which is at T, then take the diſtance N T, and meaſure it in the ſemidiameter C E from C toward E, and it wil reach almoſt to 49 degrees, which ſhews the angle of poſition to be North-Eaſterly almoſt 49 degrees.

The diſtance of the places.

Thirdly, if you would know the diſtance of the two places, you muſt with your compaſſes take the diſtance of the two places S and L, and meaſuring it in that meridian, which agrees with the angle of poſition, *viz.* 49 degrees, you ſhall finde it wil reach from A to V, now if you reckon the degrees of the parallels of latitude from A to this point V, you ſhal have the diſtance which is 52 degrees and a half.

Likewiſe you may meaſure any part of this arch S L, in this meridian A V, if you always ſet one foot in S, and open the other to the point required, and then ſet one foot in A, and the other wil ſhew the diſtance of that place. Thus the diſtances

wil

wil be found out as exactly as by any other Geometrical way, but in regard of the ſmalneſſe of the projection, you may miſtake ſome fevv miles or leagues.

But if you vvere to ſayl from the *Lizard* to the *Summer-Iſlands*, then you muſt firſt ſet dovvn the latitude of the *Lizard* on the other ſide of the circle (as I noted before) & ſo the vvork vvil ſal out much as it did before, for the longitudes and latitudes of the arch vvil be the ſame, only accounting them backvvards, the diſtance vvil be the ſame, *viz.* 53 degrees and a half, onely it muſt be meaſured in another meridian, according to the angle of poſition from the *Lizard*, vvhich vvil be about 81 degrees, ſo that in effect, all is the ſame, onely the angle of poſition, vvhich is of little uſe, but to finde out the ſcale of the diſtances. So that if you regard it vvel, one labour vvil ſerve to finde your vvay outvvard and homevvard.

The difference in ſayling forward & backward by the arch.

I might here ſhevv you hovv to perform the parallel queſtion, but becauſe ſuch queſtions may vvith more eaſe and certainty be performed by the former vvay, I ſhal not ſpend time about it, I ſhal onely inſtance in tvvo ſorts of voyages, vvhich cannot be performed by the other projection, and in ſuch caſes as theſe there vvil be ſome need of this vvay, and not elſe. Firſt, vvhen one of the places is under the Equinoctial, and the other tovvard one of the poles. The other is vvhen the one place hath North latitude and the other South.

Example of 2 places in another manner of ſcituation.

Suppoſe you were to ſail from the Iſland of St. *Thomas*, which lies under the Equinoctial, and hath about 35 degrees of longitude to the *Straights* of *Magellan*, which hath about 53 degrees of South latitude, and differs in longitude from the former place 90 degrees to the Weſt-ward: now it is required to finde out the arch of the great circle between theſe two places, and the longitudes and latitudes of this arch, with the angle of poſition, and the diſtances of the two places.

To perform this, firſt ſet down the Iſle of St. *Thomas*, which is under the Equinoctial, at the one end of the Equinoctial line at D, then accounting 90 degrees of longitude from D to E, there is the meridian of the Straights of *Magellan*, whereupon you muſt mark out the latitude thereof, which is 53 degrees

grees at W, ſo you ſhal have theſe three points D W C, by which you may finde the center, and draw the arch D W C, now this part of the circle from D to W, is the arch of the great circle, which lies between theſe two places; by which you may finde all the other things required.

As firſt for the longitudes and latitudes of this arch, they are found out by noting where it croſſeth the circles of longitude and latitude in the draught, which you ſhal finde for every tenth degree to be as in this table.

Lög	*Latitude*		*Long.*	*Latitude*		*Long.*	*Latitude*	
Deg	*D.*	*m.*	*Degr.*	*D.*	*m.*	*Degr.*	*D.*	*m.*
10	12	58	40	40	28	70	51	16
20	24	25	50	45	31	80	52	35
30	22	34	60	48	58	90	53	0

* The difference of longitude being juſt 90 deg. the angle of poſition is ready meaſured in the ſemidiameter E B being the diſtance B W, which is 37 degrees, but at other times muſt follow the rule.

Secondly, for the angle of * poſition between the two places, this is ſhewed by the arch DW croſſing the Semidiameter E B, ſo that if you take the diſtance B W, and meaſure it in the diameter C D, it wil reach from C to 37 degrees, which is the angle required, & the ſcituation ſhews it to be South weſterly.

Likewiſe the diſtance D W needs no other meaſuring, but muſt needs be 90 degrees.

Laſtly, for the diſtance of the two places, if you take the diſtance D W and meaſure it in the 37 meridian line (according to the angle of of poſition) It wil reach from A to the Equinoctial line, which ſhews the diſtance to be 90 degrees.

Example of places in another ſcituation.

The laſt example ſhal be of two places, the one being on the one ſide, and the other on the other ſide of the Equinoctiall As, ſuppoſe you were to ſail from the *Summer-Iſles*, to the Cape of good Hope, the latitude of the *Summer-Iſles*, is 32 degrees 25 North, and the latitude of the Cape of good Hope is 35 degrees ſouth, and ſuppoſe the difference of longitude between theſe two places to be 90 degrees, and it is required to find out the arch of the great circle between theſe two places, according to the longitudes and latitudes thereof, the angle of poſition and the diſtance of the tvvo places.

To perform this firſt you muſt ſet down the firſt place according to the latitude thereof in the outmoſt circle at S, and

dravv

draw the diameter *S* K, to which you muſt draw the line N M ſquirewiſe at right angles, then counting the difference of longitude which is 90 degrees from C, the meridian of the Cape of good Hope will fall in the line A B, which you muſt mark out according to its latitude 35 degrees *South* at X, then by theſe three points *S* X K, find the center which will be in the line N M extended, and ſo draw the arch *S* X K.

Now firſt, for the longitudes and latitudes of this arch you may find them by ſeeing how this arch doth croſſe the circles of longitude and latitude in the draught, which for every tenth the degree of longitude is as followeth.

Long. Deg.	*Latitude* Deg. m.	*North Latitude decreaſing.*	*Long.* Deg.	*Latitude* Deg m.	*South Latitude increaſing.*
0	32 25		50	7 19	
10	26 57		60	16 7	
20	19 40		70	23 48	
30	11 18		80	30 05	
40	02 05		90	35 0	

Then for the angle of poſition, you ſhal finde it thus, mark where the arch *S* X K, doth croſſe the line N M, which is at Z, then with your compaſſes take the diſtance Z M, and meaſuring it in the ſemidiameter C E, you ſhall finde it will reach from C almoſt to 60, *viz.* 59 degrees, 25 min. *South* eaſterly.

Laſtly, for the diſtance of the two places, if you take the diſtance of the two places in the arch *S* X, and meaſure it in this meridian, of 60, you ſhall finde it will reach from A to Y, which is 107 degrees and a half, or more exactly 107 degrees, 34 minutes.

If you make two of theſe draughts, and joyn them together, as I noted before, your work will be ſomewhat more eaſie, and readily performed. For then in any queſtion of this nature, you need but turne the Pole of the upper paper, to the latitude of the firſt place in the under paper. Then marke out the ſecond place according to its longitude and latitude, in the meridians and parallels of the under paper. Then mark what

circle of the upper paper, paſſeth through theſe two places, this is the arch required. Now the longitudes and latitudes thereof, you may eaſily ſee by its croſſing the meridians and parallels of the under paper. The diſtance of the two places, you ſhall know by counting the parallels in the upper paper between the two places. The angle of poſition is known by noting where the arch doth croſſe the Equinoctiall in the upper paper.

By this likewiſe moſt queſtions of Aſtronomy may be performed, as by the place of the Sun, to know the Declination of the Sun, his right aſcenſion, and oblique aſcenſion, his amplitude at riſing and ſetting, and by the height of the Sun to know the Azimuth and the time of the day, with many others but becauſe ſome of theſe require more exactneſſe, then any ſuch Inſtrument will afford; and likewiſe they are ſomewhat beſide my preſent purpoſe; I ſhall not now ſpeake of them.

CHAP. VIII.

How to find the arch of a great circle between any two places how ſo euer ſituate, by the projection of Tangents according to the rules of the fifth Chapter.

THough ſome of theſe arches ſpoken of in this laſt Chapter, may ſeeme at the firſt very unlikely to be deſcribed upon the Quadrant of tangents ſpoken of in the fifth Chapter: yet if you adde four of theſe Quadrants together; you may thereby make a projection of almoſt half the Globe, which may repreſent the moſt part either of the Northerne, or the Southerne Hemiſphere, and therein draw theſe lines, which ſhall repreſent the arches, not onely between any two places in one of theſe Hemiſpheres; but between any two places, though in contrary Hemiſpheres.

Indeed theſe ſtraight lines will not repreſent all the parts of theſe arches ſo viſibly as the foreſaid generall Aſtrolabe doth,

doth, failing a little in the croſſing off the Equinoctiall from one Hemiſphere into the other, becauſe the tangent line runs out there to an infinite length. But yet you may ſo proportion the Radius of your tangent, that you may come as neer the Equinoctiall as you pleaſe, but if you come within five or ten degrees thereof, it is as neer as need be. And I make this addition, becauſe the foreſaid Aſtrolabe is very troubleſome to make, eſpecially if it be large; and if it be ſmall, then the longitudes and latitudes of the Arch will not be exactly diſcerned upon it: whereas this kind of projection is more ready to be made of any largneſs you pleaſe: and not onely ſo, but though both the Inſtruments were ready for your preſent uſe, yet theſe ſtraight lines are for the moſt part more eaſily drawn upon this, then arches upon the other. * And therefore though you may uſe one of thoſe projections ſometimes for your better direction in drawing the lines upon this; yet you will find theſe more fit to ſhew the longitudes and latitudes of the arches: becauſe you may in theſe increaſe or diminiſh the degrees of latitude to what quantity you pleaſe. And it will be your beſt way to make two or three of theſe Inſtruments of a leveral Radius, the one to ſhew places of greater latitude, and the other places neer the Equinoctiall, as you ſee I have done in the former quadrant and this, this taking in much more in a little room.

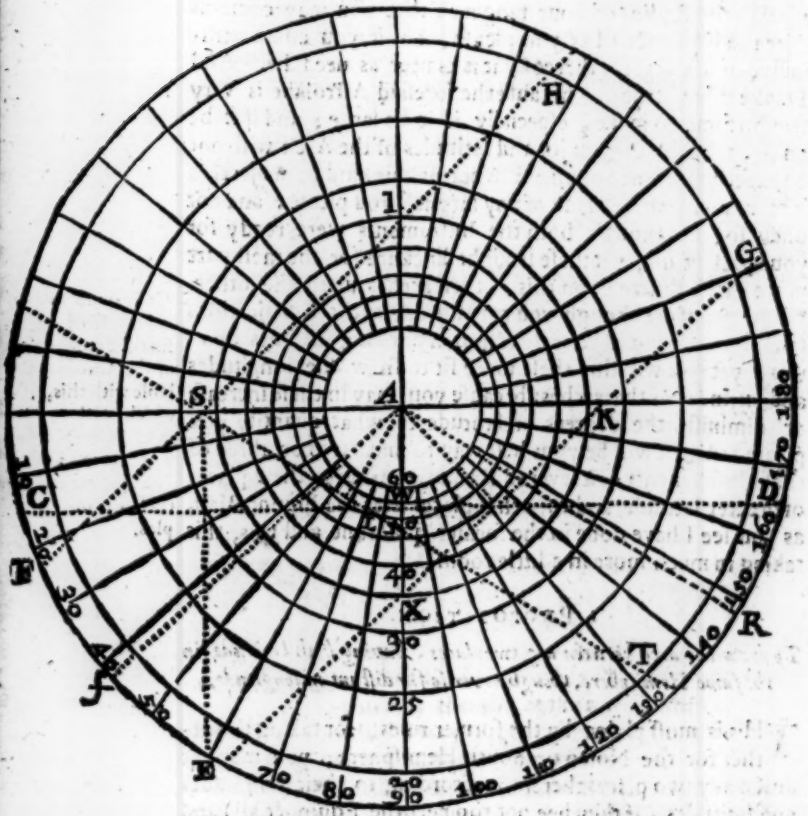
*It is good to make uſe of a ſmall draught of the Aſtrolabe with this, which will much direct you herein, as I have done in theſe examples.

1 Propoſition.

To draw the arch between any two places, having both latitude in the ſame Hemiſphere, though never ſo far diſtant in longitude.

THis is moſt plaine by the former rules, for taking this either for the North or South Hemiſphere, you may ſet down any two places therein, according to their longitudes and latitudes (if they bee not too neer the Equinoctiall) and ſo draw a ſtraight line between them, the which line ſhall repreſent that part of the arch between the two places, and ſhew the longitudes and latitudes of the ſaid arch, according as the lines of longitude, and the circles of latitude croſſe the

ſaid line of the arch ; as was before ſhewed in the fifth Chapter. Therefore it will need no further example.



2 PROPOSITION.

To find out the arch of a great circle between two places whereof the one hath latitude, and the other is under the Equinoctiall, having any difference of longitude.

FIrſt, ſeeke out the longitude and latitude of the place without the Equinoctiall, and there make a prick for it accordingly, drawing a line from the Pole, by the longitude thereof. Then from this point as your center draw your other line, which muſt make juſt ſuch an angle with this line of longitude, as ſhal be equal to the difference of longitude between the two places. So that if their difference of longitude be 90 degrees, this line muſt make right angles therewith, and if the difference of longitude be more or leſſe, the angle muſt be according.

For example, let the one place be the *Summer-Iſlands* having 32 degrees, 25 minutes of North latitude, and let the other place be under the Equinoctiall, having 90 degrees difference of longitude. Set down the *Summer-Iſlands* at *S* according to their latitude 32 degrees, 25 minutes, and becauſe the other place hath 90 degrees difference of longitude, draw the line *S* E at right angles with the line A *S*. And this line ſhall repreſent moſt part of the arch between the two places, and ſhew the true longitudes and latitudes thereof as far as your paper will give leave, which in this is but to 20 degrees of latitude, but you may continue it to 10 or five degrees of latitude, as you pleaſe.

The degrees of longitude you may number as you pleaſe, the difference of longitude is the chiefe thing, therefore I have ſet down S in the firſt meridian, whereas it ſhould be about 316 deg.

This line thus drawn is all one with the line *S* E upon the Aſtrolabe, and as that ſhewes the longitudes and latitudes of the arch, ſo doth this, which it would do more exactly if the paper were larger. The degrees and minutes of theſe longitudes and latitudes I need not ſet down, having done that before already, by which you may ſee the truth of theſe. Likewiſe ſuppoſing this to be the South Hemiſphere, the line D W C is all one with the arch in the Aſtrolable D W C; that part of the line D W, ſhewing

These examples are the ſame as before, and I have noted them with the ſame letters as neere as I can.

the longitudes and latitudes of the arch, between the Ile of St. *Thomas* under the Equinoctiall, and the Straights of *Magellan*, having 53 degrees of South latitude, as you may ſee by comparing with the Aſtrolabe, and the calculation thereof in that Chapter.

So if the difference of longitude be more or leſſe then 90 degrees, the angle muſt be according. Thus the line S F upon this, repreſents the ſhort part of the arch S *f* upon the Aſtrolabe, which cuts the Equinoctiall at 42 degrees of longitude. And the line S L T repreſents the Arch S L T upon the Aſtrolabe, which cuts the Equinoctiall at 148½ degrees of longitude, as you may ſee by drawing the line A R parallell to the line L T through the point A. * And thus alſo you may ſet off the longitude of any place which is under the Equinoctiall, or find in what longitude any circle doth croſſe the Equinoctiall, of which you will have uſe in the next Propoſition.

* Another way to ſet off the longitude of thoſe places.

3 PROPOSITION.

Two places being in contrary Hemiſpheres, to draw a line repreſenting the arch between them.

TO this purpoſe you muſt underſtand that thoſe great circles are of ſuch a quality, that if they be extended to 180 degrees, or halfe the Globe, they cut the ſame degrees of latitude in either Hemiſphere. Thus you ſee upon the Aſtrolable, that the ſtraight line S E K, and alſo the arches S L T K, and S *f* Y X K, being all great circles, all meet in the ſame degrees of latitude, (though indifferent Hemiſpheres) *viz.* at S and K, which are diſtant 180 degrees of longirude. So that if you know the one of theſe points of latitude in either Hemiſphere, the other muſt be like unto it, onely 180 degrees difference in longitude. * Which conſidered you will alwayes have two points in one Hemiſphere to draw your line by, though the places lye in different Hemiſpheres, and as you muſt have the foreſaid three points to draw the arch by in the Aſtrolable, ſo you may draw this line, having any two of the ſaid points.

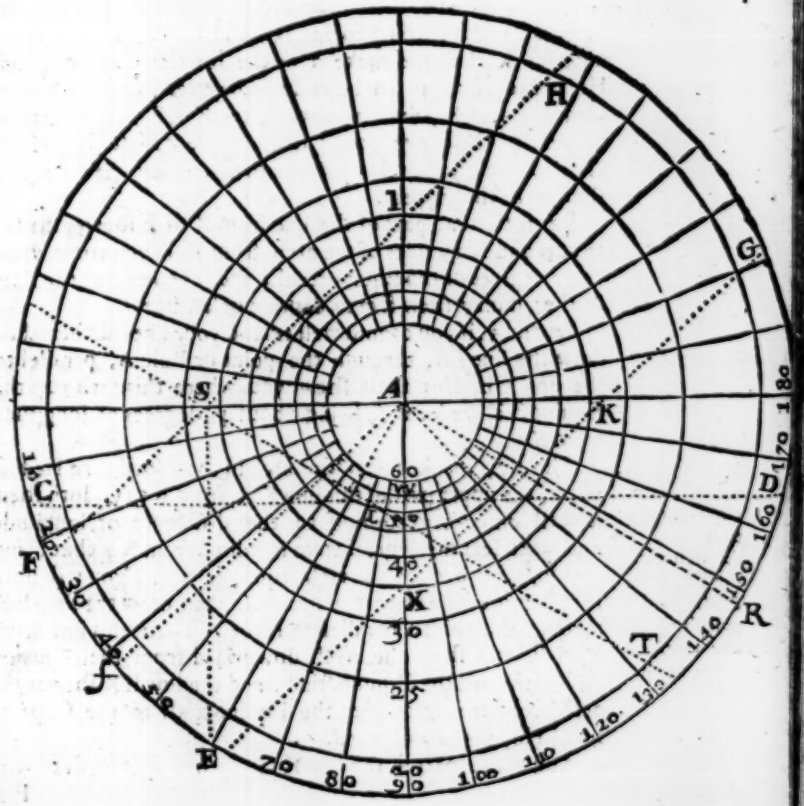
* Note this well, for though the arch requires 3 points, yet the line here requires but two; which you alwayes have, *viz.* the point oppoſed to the latitude of the firſt place, diſtant 180 deg. and the longitude and latitude of the other.

For

For inſtance take the example mentioned in the former Chapter. Let one place be the *Summer-Iſlands* having North latitude 32 degrees, 25 minutes, and the other the Cape of good Hope, having 35 degrees of South latitude, and the difference of longitude between them 90 degrees.

This example likewiſe is the ſame as before and ſet out by the ſame letters.

The great circle between theſe two places is repreſented upon the Aſtrolable, by the arch S *f* Y X K, which cuts the



ſame degree of latitude at K in the South Hemiſphere, as it doth at S in the North. So that I have theſe two places in this South Hemiſphere to draw my line by, *viz.* the place K, having *South* latitude 32 degrees, 25 minutes, diſtant 180 degrees of longitude; and the place X, having 35 degrees of *South* latitude, and having 90 degrees difference of longitude from K, as well as from S, the whole being 180 degrees.

Suppoſing therefore this to be the *South* Hemiſphere, prick down the point K therein according to his longitude 180 degrees, and according to his latitude 32 degrees, 25 minutes at K, likewiſe make a pricke for the Cape of good Hope according to its latitude 35 degrees, and longitude 90 degrees at X, and ſo draw the line K X E, this line thus drawn, by theſe two points ſhall repreſent moſt part of the arch of the great circle between the two places deſired, as I ſhall make thus appear.

For firſt, that part of the line from X to E ſhewes the latitudes and longitudes of the arch, from X till you come within 20 degrees of the Equinoctiall, and if you extend the lines further, it may ſhew five to degrees of latitude.

Secondly, if you cannot well extend your lines further, then draw the line *f* A, through the point or Pole A, parallel to the line X E, this ſhall ſhew you where this arch cuts the Equinoctiall, *viz.* at *f*, being about 42 degrees of longitude from *S*.

Note this wel, for this is the choiſe thing; to know where the arch cuts the Equinoctiall, and ſo paſſeth from one Hemiſphere to the other.

Thirdly, for the reſt of this arch in the Northerne Hemiſphere, the upper part of this line K X, from K to G, doth ſhew it well enough according to the difference of longitude and latitude if the degrees were numbred from K, that being the oppoſite part of the arch required. But if you will have it fall more neerer to the place *S*, then draw the line F S, through the point *S* parallell to K X E. Then this line from *S* to F, will ſhew the Arch downward from the *Summer-Iſlands* toward the Equinoctiall, and the line E X ſhewes the arch from the parts neer the Equinoctiall to the Cape of good Hope, as was deſired.

And as that part of the line K G, is the ſame in effect with F *S*,

F S, ſo the whole line F S I H is the ſame in effect with the line G K X E, the one being the oppoſite halfe of the Arch, to the other. So that if you had ſet off the latitude of the Cape 35 degrees at I, and drawn the line F S I H it would have given you the difference of longitudes and latitudes of the arch though not the true places of them; but in that your Chart would help, ſo that there is not much danger of miſtaking herein.

And thus you ſee how this projection doth demonſtrate the arch of a great circle between any two places however ſcituated upon the Globe, whereby you may more readily finde the longitudes and latitudes of the ſaid arch, then by any other, which being knowne, you may make thereof, pricking the ſaid arch down upon your Sea-Chart, and ſo ſteer your courſe as neer to it as you can, as I ſhewed in the fifth Chapter.

There is alſo another good uſe of this projection by tangents, & that is, that as it brings theſe arches into ſtraight lines, ſo it ſhewes how theſe lines may be found out by the doctrine of right lined triangles. (And this will be far more eaſie to underſtand and practiſe then the Doctrine of Sphericall triangles) by which theſe things have been heitherto found out; which had made this way of ſayling ſo difficult, that very few had attained to the knowledge thereof, or having known it not cared to uſe it becauſe of the trouble of calculation. But as this projection is more eaſie then any others, ſo I ſhall ſhew you a way of calculation, by the Doctrine of plaine triangles which ſhall be much more eaſie then any hitherto found out. That ſo if you thinke this Geometricall way doth not give you the longitudes and latitudes of the arch exactly enough; you may yet by the helpe of this, and a little calculation, find it out as exactly as you pleaſe. This with all other propoſitions in Navigation, you ſhall find performed with much eaſe and exactneſs in my Sea-mans Canon of Triangles; which is as a ſecond part to this. For as this performes them by Geometry, that performes them by Arithmeticke, but in a new way far more eaſie for practice then ever yet was publiſhed.

CHAP. IX.

How to keep a perfect account.

ALthough the wayes I have already shewed may be sufficient for the setting down of any reckoning upon your Charts: yet because it may be some trouble, if you often alter you rumbe, to draw a new rumbe line from every point: and besides the scale of the Chart being somewhat small, you will be subject to some mistake, in finding out the several points, & this mistake being often committed may come to some considerable errour. I shall in this Chapter shew you, how you may increase your scale, and by a little help of your pen finde out these points most exactly: and so you may set them down by the latitude, and their Basting or Westing, without drawing of the Rumbe lines, from point to point.

The way to keep a perfect account is to work by a very large Scale.

First, for the increasing of your scale, which is the chief ground whereon the certainty of your reckoning will depend. In the figure following (which is the same with the plain chart before) let each side of the square be supposed to contain but one degree of longitude or latitude (whereas before we supposed it to contain 10 degrees) so shall each degree by this means be divided into 100 very sensible parts, and be 10 times greater then the scale of your chart, by which means you shall keep your account as exactly as need be required. Then it will be necessary if you use this as an instrument to draw lines through each of these 100 parts, crossing one another as those ten lines do; but for the better distinction, you may make every tenth line bigger then the rest, and every fifth line you may prick out. Then making the corner at A the center, draw the arch of the quadrant B P 1 2 3 4 5 6 7 D, which you may divide either into 90 degrees, or else into the 8 Rumbes and their quarters, and it will be good to number them both ways, from B and D. Lastly, you must provide you a thin ruler or Index which must be divided as the side of the Quadrat is, in-

to

to 100 equall parts. You may make this Index of a piece of thin paper, and oft it: or it will be better, if you get a piece of fine Neer horn, and make a ſcale of equal parts thereon, equal to the ſides of the quadrat, and ſo faſtening it to the enter A, you may turn it to any Rumbe in the arch, and very plainly ſee all the lines of the Inſtruments through it.

The uſe of this Inſtrument might be ſhewed in many propoſitions, but I ſhall onely ſhew you how to uſe it in two very neceſſary propoſitions, by the one of which you may keep your dead reckoning, by the other your true reckoning by obſervation.

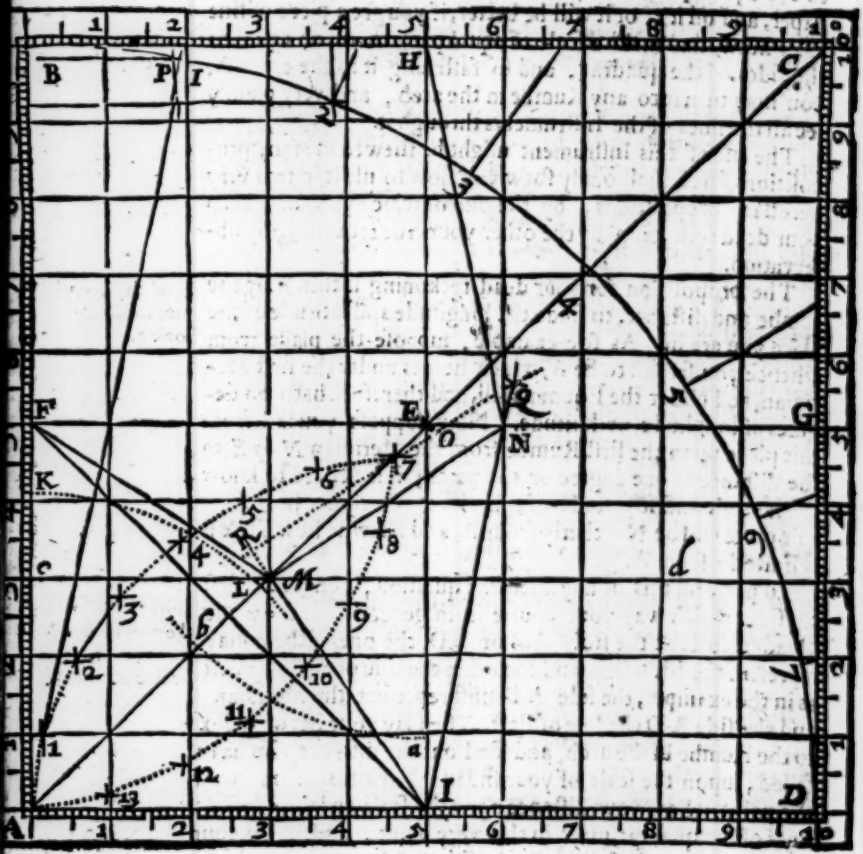
How to keep your dead reckoning.

The propoſition for your dead reckoning is this. By the rumbe and diſtance, to finde the longitude and latitude of the place you are in. As for example, ſuppoſe the place from whence you ſet ſail to be A, which here is under the firſt Meridian, and under the Equinoctiall, and therefore hath 00 degrees of longitude or latitude. Now ſuppoſe you ſail from this place upon the firſt Rumbe from the Meridian *N by E*, to the diſtance of one degree or 100 parts; it is deſired to know the latitude and longitude of this place. Or rather how farre this place will be Northerly from A, and likewiſe how farre it is Eaſterly from A.

How to work the propoſition upon the Inſtrument.

To perform this or any ſuch like queſtion, you muſt firſt conſider which way your courſe is in generall, and lay the Quadrat ſo that the ſides A B or A D, the one of them may repreſent the Meridian, and the other the line of Eaſt or Weſt as in the example, the ſide A B muſt repreſent the Meridian, and the ſide A D the line of Eaſt. Then lay your horne Index to the Rumbe in the arch, and find out the diſtance you have ſailed, upon the ſcale of your Index. Now marke very well the point, where your diſtance upon the ſcale ends, and what lines of the quadrat meet in this very point, and if by your eye, you trace theſe lines to the ſides of the quadrat, the figures there, will ſhew you the Northing or Southing, Eaſting or Weſting as the queſtions requires.

As in this example, becauſe your courſe in general is North-Eaſterly, let the ſide A B repreſent the North Meridian line,



so the side A D, at the bottome, or B C at the top, will represent the lines of easterly longitude or distance. Then because your course is *N b y E*, which is the first rumbe from the North Meridian

Meridian Eaſtward, lay your horn Index upon the firſt rumbe from the line A B, which is the line A P. Then count your diſtance which is one degree or 100 parts upon your Index, and marke where this number ends, which is in the point P, where the line A P croſſeth the arch B P. This is the exact point where you are. Now if you trace the line P B that runs through this point to the Meridian line, you ſhall there finde that you are to the Northward of the place A 98 parts of a degree divided into 100 parts, likewiſe if you trace the line that runs through this point P to the bottome or top of the quadrat, there you ſhall finde that you have altered your longitudes $\frac{12}{100}$ parts and a half.

How to ſet the Northing and Eaſting found out, upon the Chart.

Having thus found out the exact *N*orthing and Eaſting of this place from A, we will now (to avoid the inſerting of another figure) ſuppoſe this laſt to be a plain Chart again, having each ſide divided into 10 degrees as before, and if you ſet down this place by the firſt propoſition of the plain Chart, according to the latitude and longitude thus found out, *viz.* latitude 00 degrees 98 parts, & longitude 00 degrees 19 parts and a halfe, you ſhall finde that its place will be cloſe by the corner A, at the figure 1. Likewiſe for your better proceeding afterwards, you may write down the longitude and latitude of this place 1, as you may ſee in the table following.

Another example in the ſame voyage.

*N*ow ſuppoſe that you alter your courſe at this place 1, and ſail from hence *N N E*, which is the ſecond rumbe from the meridian one degree, or 100 parts more. And it is deſired to know the longitude and latitude of this ſecond place.

To know this lay the Index upon the ſecond rumbe from the meridian line A B, and count upon it your diſtance ſayled, which is 100 parts, and obſerving well where this diſtance ends, which is where the line of the ſecond rumbe doth cut the arch B P, which is in the croſſe at 2: this is the point that ſhews you the difference of longitude & latitude of this place from the laſt. *N*ow by the lines that paſſe through this croſſe, you ſhall ſee the difference of latitude to be 92 parts, and the difference of longitude to be 38 parts. *N*ow if you would know the true longitude and latitude of this place, in reſpect of the

first place A, that ſo you may ſet it down upon your chart; you muſt add the Northing and Eaſting of both the places together thus.

From A to 1 *N by E* 100 parts is,	*North* 98.	*East.* 19 1/2
From 1 to 2 *N N E* 100 parts is,	*N.* 92.	*E.* 38
The Summe of both is	1,99	57 1/2

So that the latitude of this ſecond place is 1 degree 90 parts of North latitude and 0 degrees 57 parts and a half of longitude. And then ſetting it down according to the firſt propoſition, of the plain chart, you ſhall finde this place to be at the figure 2 neer the corner A.

And thus you ſhall finde out the point of any place in your chart more certainly then other ways it is poſſible for you to do, and with leſſe trouble, as you may ſee by the table following of the reſt of the places, 3 4 5 6 7 in the chart.

Note this well.

But here you muſt obſerve that as in theſe places where the latitude & longitude doth ſtill increaſe, you make uſe of Addition, ſo if your courſe lies ſo, that the longitude and latitude both decreaſeth, you muſt make uſe of Subſtraction both in longitude and latitude. And ſomtimes the courſe may lye ſo, that the longitude may increaſe, and the latitude may decreaſe, then ye muſt add the one, and ſubſtract the other. Your beſt rule to guide you in this, when to add and when to ſubſtract is to obſerve your courſe in general, which way it tends, which you may eaſily ſee by your Chart.

Example.

As for example being come to the place 7 in the chart, whoſe latitude is 4 degrees, 57 parts, and the longitude thereof is 4 degrees, 57 parts, and from this place you ſail *S by W*, that is, upon the firſt Rumbe from the Meridian to the Weſtward, 100 parts, and it is deſired to know what longitude and latitude you are then in.

To perform this, firſt you may ſee by your courſe in general, which is South-weſterly from the place 7, that both the longitude and latitude of the place you ſail to muſts needs decreaſe, and therefore the difference of longitude and latitude which you ſhal finde out by the Inſtrument, muſt be ſubſtract-

ed

ed from the longitude and latitude of the place 7, that so you may have the true longitude and latitude thereof. Now having considered this; by your quadrat you shall finde that the course being the first rumbe from the Meridian, and the distance being 100 parts, the difference of latitude will be 98 parts, and the difference of longitude 19 parts and a half: this substracted from the longitude and latitude of 7, shews the longitude and latitude of the place 8 where you are.

The place 7 hath latitude	4 deg.	57 parts.	long. 4 deg.	57 p.
Subst. the differ. of latitud.	0	98	long. 0	19 ½
Rest for the place 8 latit.	3	59	long. 4.	37 ½

Thus likewise you must do to finde the longitude of the other places 9 10 11 12 13 A. * And it will be a great help to direct you when to add, and when to substract, if you joyn four of these quadrats together, which you may very well do, if in a large sheet of paper, you draw a large circle with your compasses, and dividing it into four parts, make each of them like to this, and set the names of the points of the compasse to the rumbes, as in the figure of the compasse *pag.* 10. By this means without any trouble you shall plainly see the Easting and Westing, the Northing and Southing of your course.

* A good way for young beginners to avoid mistakes.

But now for the better setting down of these distances, you must divide your table into four columns, for the four principal quarters, East, West, North, South, and set down therein according to their titles, the Easting or Westing, the Northing or Southing of your course, which you finde by the Instrument, and then in casting up your accounts, you must add altogether that you finde under one columne, but if you have any summes in contrary columns, as East and West, or North and South, you must substract the summe of the East from the summe of the West; and the summe of the North columne from the summe of the South, so often as you would finde the longitude and latitude of the place where you are, as you may see by this following table of all the voyage outward and homeward.

How to set down these distances in a table.

The

Compare this table and the Chart wel together.

	Course.	dist. d pa.	Nor, d. pa.	Sou, d. pa.	East, d. pa.	west. d. pa.	Lat. d. pa.	Lon. d. pa.
The place A							0, 00	0, 00
from A to 1	*N by E*	1, 00	0, 98		0, 19		0, 98	0, 19
from 1 to 2	*N N E*	1, 00	0, 92		0, 38		1, 90	0, 58
from 2 to 3	*N E by N*	1, 00	0, 83		0, 55		2, 73	1, 13
from 3 to 4	*N E*	1, 00	0, 71		0, 71		3, 44	1, 84
from 4 to 5	*N E by E*	1, 00	0, 56		0, 83		4, 00	2, 67
from 5 to 6	*E N E*	1, 00	0, 38		0, 92		4, 38	3, 59
from 6 to 7	*E by N*	1, 00	0, 19		0, 98		4, 57	4, 57
from 7 to 8	*S by W*	1, 00		0, 98		0, 19	3, 59	4, 38
from 8 to 9	*S S W*	1, 00		0, 92		0, 38	2, 67	4, 00
from 9 to 10	*S W by S*	1, 00		0, 83		0, 55	1, 84	1, 44
frō 10 to 11	*S W*	1, 00		0, 71		0, 71	1, 13	2, 73
frō 11 to 12	*S W by W*	1, 00		0, 56		0, 83	0, 57	1, 90
frō 12 to 13	*W S W*	1, 00		0, 38		0, 92	0, 19	0, 98
from 13 to A	*W by S*	1, 00		0, 19		0, 98	0, 00	0, 00

Thus I hope you see by this table, how that by adding or substracting, the Northing, Southing, Easting or Westing, to, or from the longitude and latitude of the place before, you may still finde out the longitude and the latitude of the place you are in, for the keeping of your dead reckoning, as exactly as need be required.

How to find out the true point of your longitude, by observation of the latitude.

Now the other Proposition which is usefull in the rectifying of your account, according to your observation is this. By the rumbe and the difference of latitude, to finde the longitude of the place where you are, and the distance of this place from the other. Now the way of working this Proposition upon the quadrat is this, First, you must suppose one of the sides to be the meridian line, and the other to be the line of East or West as before, then lay your Index to the degree of the Rumbe, on which yon have sailed, and keep it there.

Then

Then count upon the Meridian line from A, the difference of latitude of this place you are in (according to your obſervation) from the place you came laſt, and note where this number ends, and marke well the line that is drawn from the place, and trace it to your Index, and this point where this line croſſeth the Index, is the point where you are. Now if you count the parts upon your Index from A to this point, ſo you ſhall ſee the true diſtance you have ſayled in that Rumbe. And if you trace the line that runnes through this point to the line of longitude at the top or bottome of the Inſtrument, there you ſhall ſee the difference of your longitude, or rather how farre Eaſtward or Weſtward it is from the former place.

For example, ſuppoſe you ſayled from the place A. (whoſe longitude and latitude let be as before) *N by E*, that is upon the firſt Rumbe from the Meridian, ſo long, till by obſervation you found you had altered you latitude 98 parts of a degree divided into 100 parts: and your deſire to know how far you have ſailed in the Rumbe; and how far you are to the Eaſtward of the place A. *Example.*

Firſt, lay your Index upon the line A P, which is the firſt Rumbe from the Meridian, and keep it there, then count the difference of the latitude, which is 98 parts, in the meridian line from A to B, then marke the line that is drawn from this part, and obſerve well where it croſſeth the Index or Rumbe line, which is in the point P, and this is the very point where you are. Now if you count the parts upon your Index from A to this point, you ſhall finde your diſtance ſailed to be 100 parts or one degree. And if you marke the line that runs through this point to the line of longitude, you ſhall there ſee the difference of longitude which is 19 parts and a half to the Eaſtward from A, thus the propoſition is fully reſolved.

But in this propoſition you muſt take notice, that if you ſail upon ſeveral Rumbes before you obſerve the latitude, then firſt you muſt find out the Rumbe which lies from your firſt place, to the place where you are according to your dead reckoning (as is ſhewed in the ſixt propoſition of the Plane Chart) and then laying your Index upon this Rumbe, worke as aforeſaid.

How to work when the question is of more then 100 parts.

Note that in working of either of these propositions by the quadrat, if the distance or difference of latitude be more then a degree or 100 parts, then you may first finde out what belongs to one degree, and then what belongs to the odd parts, and adding them together, you may finde the truth as exactly, as if your Instrument were large enough to shew both at once. But if your distance or difference or latitude be four or five degrees, you may then very well work the proposition upon your chart, without using the quadrat, and need not fear errour, if you be any thing carefull, and work by a true scale of rumbes and equall parts.

How to perform these two propositions in all latitudes.

Hitherto I have shewed you how to worke these two propositions upon the plane chart, or in places neer the Equinoctial: But because the degrees of latitude in the true Sea-chart must not be all of one and the same length, therefore neither can the true latitude nor longitude of places be set down by one and the same scale of equall parts. Therefore I shall now shew you, how when you have found out the Northing or Southing, Easting or Westing of any place, as is before shewed by the quadrat, how you shall set it down in any latitude that it may shew the true longitude thereof. For you must know, that though the Northing and Southing, doth shew the true difference of latitude in all latitudes: yet the Easting and Westing found out by the quadrat, doth not shew the true difference of longitude in those places, which are any thing distant from the Equinoctiall, I shall therefore shew you how to performe these two Propositions in all latitudes.

First, for the dead reckoning.

For example, of the first Proposition. Suppose you were at the place H, in the following figure, whose longitude is under the first Meridian, but it lies in 45 degrees of North latitude, and suppose you should sail from this place *N by E* to the distance of 100 parts, as before said, and is desired to finde the latitude and longitude of this place.

The first way to perform this by the Chart it self.

First, you must finde out the Northing and Easting by the quadrat as is before shewed. Now the Northing of this course being 98 parts, must be added to the latitude of the former place 45 degrees, so the latitude you are in will, be known to

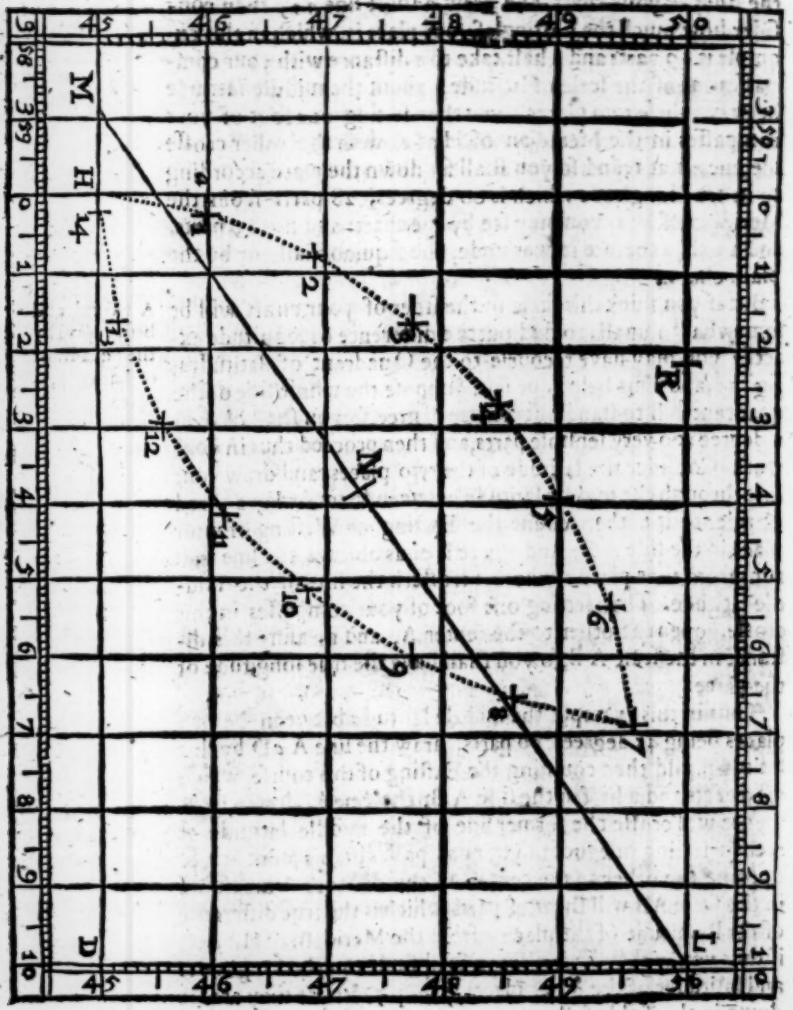
be

be 45 degrees, 98 parts, then lay your Ruler to this latitude in the ſides of your chart, and draw a ſhort line *a* 1, then conſider how much the Eaſting of your place is, which in this example is 19 parts and a half, take this diſtance with your compaſſes out of the ſcale of latitude, about the middle latitude between theſe two places, and then ſetting one foot of your compaſſes in the Meridian of H at *a*, with the other croſſe the line *a* 1 at 1, and ſo you ſhall ſet down the place according to its true longitude which is 00 degrees, 28 parts from the Meridian of H, as you may ſee by the chart: and not 19 parts, and a half, as before it was under the Equinoctiall, or by the plain chart.

A ſecond and better way, by the quadrant of Latitude, *pace.*

But if you think this ſcale in the ſides of your chart will be ſomewhat to ſmall to find out the difference of longitude exactly you may have recourſe to the Quadrant of latitudes, *pag.* 32, and thus help your ſelf. Suppoſe the whole ſide of the quadrant A B to ſtand but for one degree, ſo you ſhall have in a degree 100 very ſenſible parts, and then proceed thus in your work. Conſider the latitude of the two places, and draw your line through the middle latitude between them, or lay a thred or ruler to it: then count the Eaſting or Weſting of your place in the ſide A B, and where it ends obſerve the line that runs from that place, where it croſſeth the line of the middle latitude. Then ſetting one foot of your compaſſes in this croſſe, open the other to the center A, and meaſure this diſtance in the ſcale A B, ſo you ſhall have the true longitude of the place.

Thus in this example, the middle latitude between the two places being 45 degrees, 50 parts, draw the line A *c* D by this latitude, and then counting the Eaſting of this courſe, which is 19 parts and a half in the ſide A B, the line *b c* drawn from thence will croſſe the former line of the middle latitude at *c*, then ſetting one foot in your compaſſes in this point at *c*, & opening the other to the center A, this diſtance A meaſured in the ſcale A B will ſhew 28 parts, which is the true difference of the longitude of the place 1 from the Meridian of H. And if thus you will make triall, you ſhall finde out the longitudes and latitudes of the other places, 2 3 4 5, &c. as they are ſet down in the Table following.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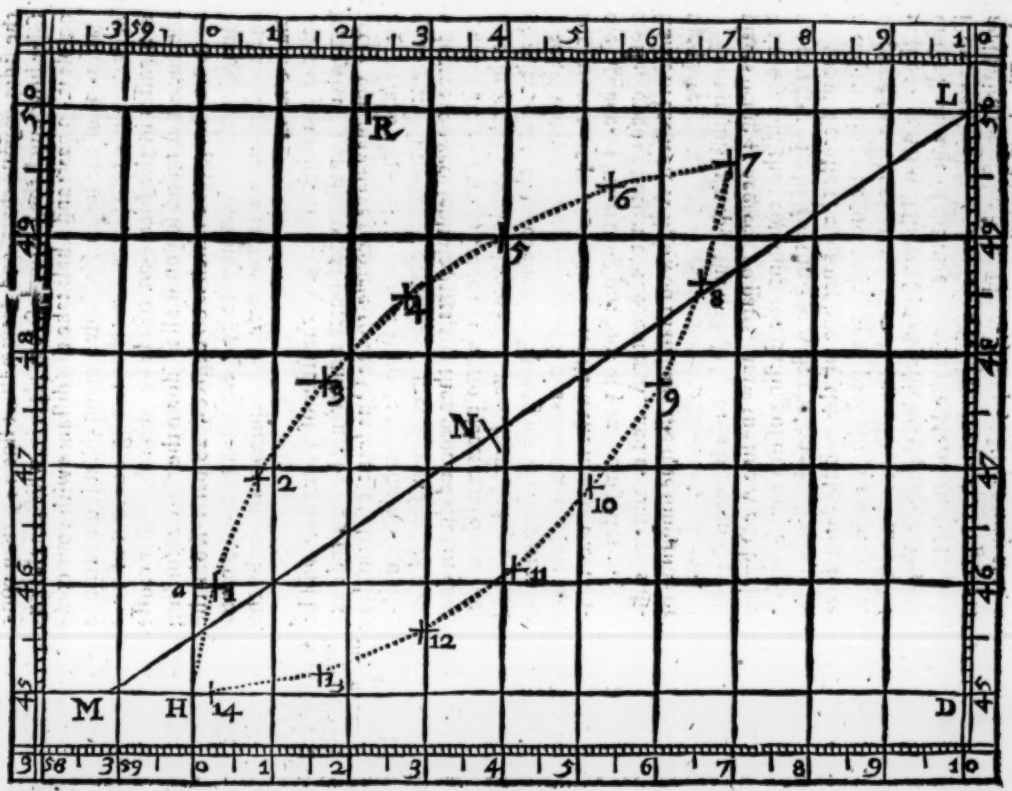
	Course.	dist. d. pa.	Nor, d. pa.	Sou, d. pa.	East, d. pa.	west. d. pa.	Lat. d. pa.	(*) d. pa.	Lon. d. pa.
The place H							45,00		0,00
from H to 1	*N by E*	1,00	0,98		0,19		45,98	0,28	0,28
from 1 to 2	*N N E*	1,00	0,92		0,38		46,90	0,54	0,82
from 2 to 3	*NE by N*	1,00	0,8		0,55		47,73	0,82	1,64
from 3 to 4	*N E*	1,00	0,71		0,71		48,44	1,06	2,70
from 4 to 5	*N E by E*	1,00	0,56		0,83		49,00	1,24	3,94
from 5 to 6	*E N E*	1,00	0,38		0,92		49,38	1,41	5,35
from 6 to 7	*E by N*	1,00	0,19		0,98		47,57	1,50	6,85
from 7 to 8	*S by W*	1,00		0,98		0,19	48,59	0,30	6,55
from 8 to 9	*S S W*	1,00		0,92		0,38	47,67	0,57	5,98
from 9 to 10	*S W by S*	1,00		0,83		0,55	46,84	0,82	5,16
frō 10 to 11	*S W*	1,00		0,71		0,71	46,13	1,02	4,14
frō 11 to 12	*S W by W*	1,00		0,56		0,83	45,57	1,19	2,95
frō 12 to 13	*W S W*	1,00		0,38		0,92	45,19	1,31	1,64
frō 13 to 14	*W by S*	1,00		0,19		0,98	45,00	1,39	0,25
from 14 to H	*West.*	0,17				0,17	45,00	0,25	0,00

This table agrees with the former in most things, the chief difference is in the longitude, which must be thus found out. By the Easting or Westing of your course, you must finde out the difference of the longitude therof according to the middle latitude, and set it in the table under the last column, but one, noted thus (*) and this difference added or substracted as it ought to be in the last columne, shews the true longitude of the place where you are. This will be your best way to keep your dead reckoning.

Note the difference of this Table from the former.

Now for the secoud proposition, which is by the Rumbe, and the difference of latitude; to finde the difference of longitude, and the distance. To perform this, first knowing the latitudes of the two places, draw a line in your Quadrant of latitude, by the middle latitude of the two places. Then count the difference of the latitude in the scale of the quadrant of latitude, A B, and where the number ends, draw or

How to perform the second proposition in all latitudes.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	Course.	dist. d. pa.	Nor, d. pa.	Sou, d. pa.	East, d. pa.	west. d. pa.	Lat. d. pa.	(*) d. pa.	Lon. d. pa.
The place H							45,00		0,00
from H to 1	*N by E*	1,00	0,98		0,19		45,98	0,28	0,28
from 1 to 2	*N N E*	1,00	0,92		0,38		46,90	0,54	0,82
from 2 to 3	*NE by N*	1,00	0,8		0,55		47,73	0,82	1,64
from 3 to 4	*N E*	1,00	0,71		0,71		48,44	1,06	2,70
from 4 to 5	*N E by E*	1,00	0,56		0,83		49,00	1,24	3,94
from 5 to 6	*E N E*	1,00	0,38		0,92		49,38	1,41	5,35
from 6 to 7	*E by N*	1,00	0,19		0,98		47,57	1,50	6,85
from 7 to 8	*S by W*	1,00		0,98		0,19	48,59	0,30	6,55
from 8 to 9	*S S W*	1,00		0,92		0,38	47,67	0,57	5,98
from 9 to 10	*S W by S*	1,00		0,83		0,55	46,84	0,82	5,16
frō 10 to 11	*S W*	1,00		0,71		0,71	46,13	1,02	4,14
frō 11 to 12	*S W by W*	1,00		0,56		0,83	45,57	1,19	2,95
frō 12 to 13	*W S W*	1,00		0,38		0,92	45,19	1,31	1,64
frō 13 to 14	*W by S*	1,00		0,19		0,98	45,00	1,39	0,25
from 14 to H	*West.*	0,17				0,17	45,00	0,25	0,00

This table agrees with the former in most things, the chief difference is in the longitude, which must be thus found out. By the Easting or Westing of your course, you must finde out the difference of the longitude therof according to the middle latitude, and set it in the table under the last column, but one, noted thus (*) and this difference added or substracted as it ought to be in the last columne, shews the true longitude of the place where you are. This will be your best way to keep your dead reckoning.

Note the difference of this Table from the former.

Now for the secoud proposition, which is by the Rumbe, and the difference of latitude; to finde the difference of longitude, and the distance. To perform this, first knowing the latitudes of the two places, draw a line in your Quadrant of latitude, by the middle latitude of the two places. Then count the difference of the latitude in the scale of the quadrant of latitude, A B, and where the number ends, draw or

How to perform the second proposition in all latitudes.

obſerve the line drawn from it, where it croſſeth the line of the middle latitude, then taking this diſtance in your compaſſes, meaſure it in the ſcale A B (increaſed if need be) then work with this number upon the quadrat as is ſhewed before *pag.* 97, as if this number were the true difference of latitude between the two places, ſo you ſhall finde out the true difference of longitude in degrees and parts. And for the true diſtance, if you obſerve the parts of the Index of the quadrat at theſe points, and meaſure them in the line of the middle latitude, the line that runs from this point to the ſcale of the quadrant, will ſhew the true diſtance.

For example, let the place from which you ſail be H, in the latitude of 45 degrees, let the Rumbe you ſail upon be *N by E* and let the difference of latitude be 98 parts: and it is required to finde the true difference of longitude, and the diſtance of this point.

Firſt, in the quadrant of latitude, draw the line A Z, by the middle latitude of the two places; which is 45 degrees, 49 parts, then in the ſcale of the quadrant A P (counting the whole ſcale or Radius for one degree) reckoning the difference of latitude 98, and obſerve the parallel line that comes from this where it croſſeth the line of the middle latitude which is at Z. Then ſetting one foot of your compaſſes in this point Z, open the other to the center A, and meaſure this diſtance in the ſcale A B lengthened, and you ſhall finde it to be 140 parts: thus the true difference of latitude 98 parts is inlarged to 140 parts; which is the proportion it ought to have in this latitude. Then working with this difference of latitude inlarged upon the quadrat, as was ſhewed *pag.* 97 and 100, firſt, for 100 parts, I finde the difference of longitude to be 20 parts, and the diſtance upon the Index is 101 parts, then likewiſe for the 40 parts; I finde the difference of longitude to be 8 parts, and the diſtance on the Index is altmoſt 41 parts. Theſe two ſummes added together makes the true difference of longitude to be 28 parts, and the diſtance 143 parts almoſt. Now, laſtly, this diſtance meaſured in the line of the middle latitude, in the quadrant of latitude,

will

will reach from A to D, and the line that runs from this place up to the ſcale A B ſhews the true diſtance ſailed, which is one degree or 100 parts.

Thus having found out by obſervation at any time the true latitude of the place where you are, if it ſhall differ from your latitude by dead reckoning, you may finde exactly in what point you are in reſpect of the longitude as well as the latitude. And though ſome of theſe things may ſeeme at the firſt a little difficult; yet if you conſider well, all that hath bin ſaid before, and ſo underſtand the firſt principles of the Worke, you ſhall finde, that a *little* practiſing of theſe queſtions, and ſome ſuch like, which you may propoſe to your ſelfe, will make all very plain and eaſie.

F I N I S.

ERRATA.

Pag. 2. l. 7. for E read K, pag. 3. l. 6. for P A is, read is P A, p. 25. l. 25. for for, read from, p. 26. l. 16. for $\frac{15}{100}$ read $\frac{65}{100}$, p. 28. l. 4. read if you know, p. 28. l. 11. read, at two, p. 32. l. 8. for part A C, read part A E, p. 35. in the Table of the Meridian line for 31. d. read 32. 63. pag. 39. l. 10. for line read like, p. 40. l. 27. read whereas there. p. 43. l. 17. for $\frac{2}{10}$ read $\frac{3}{10}$, pag. 49. l. 5. read places as theſe l. 16. $\frac{33}{100}$, pag. 55. In the Table the deg. ſhould begin thus. 300. 305. 310. p. 64. l. 29. read 4. deg. $\frac{2}{10}$, p. 65. l. 25. for long read lone Iſland p. 68. l. 23. for 20. read 36. deg. line 24. for 20. read 40. deg. p. 74. l. 30. read other foot. line laſt. for 4 read 45. deg. p. 83. l. 14. read, the arches. p. 89. l. 13. read, make uſe thereof.

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